PRINCIPLES
OF
CHEST X-RAY DIAGNOSIS

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TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

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I wish to acknowledge the help and encouragement I have received from all the clinicians whose cases have enabled me to learn something about the causes of the various shadows seen in radiographs

I am also particularly indebted to those pathologists who have spent much time and trouble on correlating the abnormal shadows seen with the morbid anatomy and the histological features of the lesion namely to R J R Cureton and W J Hanbury for the histology of the various tuberculous lesions and the lung changes associated with bronchial carcinoma to J W Clegg for endobronchial tuberculosis to G J Cunningham for tuberculosis and bronchiectasis and to Lynne M Reid for bronchiectasis chronic bronchitis emphysema bullae and certain cases of mitral stenosis in which line shadows are seen above the costo phrenic recess

I am indebted to Sully Hospital for Fig 114 and to St Thomas s Hospital for Fig 131

The illustrations are from photographs prepared from the original radiographs by D F Kemp in the photographic department of the Institute of Diseases of the Chest the Brompton Hospital

The References given are only a faint indication of my debt to the work of others Most of the references are key ones which themselves refer to the work of others on that particular subject

LONDON 1956 GEORGE SIMON

INTRODUCTION

THIS BOOK is written for the student radiologist and for the clinician who is particularly concerned with chest diseases whether he interprets the radiographs himself or has the co operation of a radiologist

The material has been arranged under headings descriptive of the x ray shadows rather than under the clinical disease labels since the author believes this to be the most useful grouping from the standpoint of x ray diagnosis

Confronted with an abnormal shadow the observer s first obligation is to give a factual report on what he sees or thinks he sees in regard to its size shape position and other characteristics and also its effect on surrounding or nearby normal shadows A statement of this kind or an equivalent diagrammatic drawing is necessary in the patient s interest since it is a record of what was seen at the time should the radiographs be mislaid and an indication of the basis from which diagnostic conclusions were drawn A certain amount of observer error is inevitable at this stage

In the second stage—that of interpretation—the pitfalls are legion There is usually an obligation to define the anatomical site or the nature of the underlying pathological process and finally to correlate any tentative conclusions thus drawn with the clinical picture This done the final diagnosis may be at once apparent or may be arrived at gradually after further clinical and radiological investigations

The sections in this book take this same course each type of shadow being in turn described factually and then discussed from the point of view of interpretation and misinterpretation It is the author s hope that this particular approach to the subject of chest radiology may help the reader to extract the maximum value from what is after all an important ancillary aid to diagnosis

DEFINITION OF TERMS

Then you should say what you mean the March Hare went on I do Alice hastily replied at least—at least I mean what I say—that s the same thing you know
Not the same thing a bit ! said the Hatter

Lewis Carroll

That the writer of an x ray report does not always say what he means is often due to confusion over the precise meaning of the terms which he uses Certain words are expected to convey a quantity of subsidiary ideas which is not justified and many words are used to describe x ray shadows which properly pertain to morbid histology There is atelectasis of the left upper lobe will be frequently found in an x ray report Does this mean that there is a shadow giving evidence of lobar shrinkage ? Does it imply only that the lobe is airless with the alveolar walls more or less in apposition or does it also suggest that the airlessness is due to bronchial occlusion ? Does it exclude or allow for some alveolar exudate or transudate that is consolidation or even dilated mucus filled bronchi ?

It is not unknown for expressions to be deliberately vague or even misleading There is infiltration in the right upper zone for example is a favourite way of shelving the problem only too prominent in the writer s mind of whether shadows are tuberculous before there is any clinical proof of this or whether there is any radiological proof that they are in the lung at all

There are of course sources of confusion other than verbal ones to account for the high observer-error figures found in so many carefully controlled experiments (Garland 1951 Newell and his colleagues 1954) False conclusions are drawn from correct observations Observers may be asked to determine from an initial radiograph whether there is an abnormal shadow present or not and may interpret a shadow as a pathological lesion when in fact it is a normal shadow accentuated by slight rotation of the patient Or again observers may be asked to discover from a pair of radiographs taken at an interval of 3 months whether the patient s condition is better worse or unchanged In the last of the two radiographs the shadow may be smaller and may be thus recorded by two observers but wher

observer may conclude that this indicates improvement the other may conclude that it indicates bronchostenosis and atelectasis and therefore deterioration

Finally some errors may occur through failure to notice the shadow at all because it is indistinct or partly obscured by superimposed normal shadows because inspection of the radiograph was too hurried or because the observer s attention was distracted by other shadows or blunted by being focused too long on normal radiographs during a rushed session of work Errors due to this cause can be greatly reduced if all radiographs are seen by two observers and less reliance is placed on a single observer and a single anterior view radiograph to exclude a significant lesion

Humility is certainly required regarding the supposed accuracy of all observers in detecting and describing common abnormal shadows on radiographs To deal with only one side of the problem it would be an advantage if certain words commonly used in x ray reports could be given a more definite meaning by general agreement In the meantime pending this happier state of affairs a definition of terms is given below for use when reading this book

Atelectasis

Synonyms—collapse incomplete expansion

In this book the word will be used only in the sense of absorption atelectasis meaning that the air is absorbed from the alveoli which may occur if a bronchus is occluded (Kerley 1951) It will not be used in relation to passive collapse or relaxation as under a pneumothorax

The pathological state of a lobe distal to occlusion of the lobar bronchus is variable and there is rarely just airlessness alone but also varying degrees of distal bronchiectasis intra alveolar oedema and pneumonia In fact unless these latter conditions are present or unless the degree of shrinkage is very great no shadow will be seen (Dornhorst 1954)

Atelectasis is broadly speaking, airlessness with shrinkage In either case there may or may not be bronchial occlusion and the most that the radiologist can do when confronted with such a shadow is to see whether there is an associated shadow which might indicate the possibility of bronchial occlusion or to try and demonstrate or exclude this by tomography or bronchography unless it is about to be or already has been demonstrated by bronchoscopy

Lobar shrinkage without occlusion of the lobar bronchus is illustrated in Fig 61 and bronchial occlusion with little lobar shrinkage in Fig 72

If bronchial obstruction has already been demonstrated the term obstructive atelectasis may be used in reference to the radiographic appearance of a homogeneous shadow with evidence of lung shrinkage

Prefixes to the word atelectasis which will not be used in this book

The following prefixes are often attached to the word *atelectasis* in x ray reports but are considered an unsatisfactory way of describing an x ray shadow because the underlying pathology is variable and cannot be deduced with any certainty from the radiograph They will not be used in this book

Compression atelectasis—Synonyms—passive collapse collapse Used in relation to the state of the lung under a pneumothorax The increase in external pressure is only relative and since there is still a negative intrapleural pressure the word compression is really unsuitable The condition will be referred to as relaxation of the lung

Mantle atelectasis—Zones of airless alveoli some with evidence of lung shrinkage and some with oedema and consolidation without shrinkage are seen by the morbid histologist round nearly every lesion be it a pneumonic focus a cavity (mantle atelectasis) or a neoplasm These airless zones are often microscopic in size and too small to be demonstrable on a radiograph Whenever a shadow is described in this book only the main pathology will be indicated and very small airless areas will be ignored

Focal atelectasis—Small areas of airless lung are found histologically in chronic bronchitis emphysema some pneumoconioses and many other conditions They may be small areas of absorption atelectasis or of relaxed lung compressed by surrounding bullae or areas of consolidation They are either invisible on the radiograph or are masked by the more spectacular surrounding lesions so that there would be no occasion to use the expression to describe multiple small shadows in an

x ray report A single sub segmental area of airless lung might be described as a focal atelectasis but might equally well be described as a Fleischner s line or linear atelectasis

Plate or linear atelectasis—This description has been given to a small linear shadow which is often seen running horizontally in a lower zone (Fleischner 1941) The pathology of these lesions however is mixed and the range of change is evenly balanced between airlessness alveolar exudates with or without lung shrinkage fibrotic organization and indrawn or thickened pleura No useful purpose is served by labelling the shadow after one set of changes rather than another

Contraction atelectasis—This is a theoretical condition said to be the result of pulmonary spasm and presumably not just bronchial shortening from contraction of the longitudinal muscles of the larger bronchi Being functional no morbid histological proof of the existence of the condition is available

Congenital atelectasis—This condition differs from absorption atelectasis in that there never has been air in the affected alveoli The area of opacity is caused by the failure of a lobe or the whole of one lung to aerate and expand when breathing was first initiated The term failure to aerate is more descriptive in such a case

Bronchial occlusion

Synonym—complete obstruction of the bronchus

This may be the result of an intraluminal foreign body or of an organic disease of the bronchial wall particularly tuberculous endobronchitis and neoplasm or of extrinsic pressure most often from an enlarged or healing gland The result of the occlusion of a main lobar or sometimes segmental bronchus is airlessness with atelectasis (collapse) of the lung distal to it The occlusion may be permanent or temporary should it be relieved the lung will sometimes recover though the damage is often irreversible

Bronchostenosis

Synonym—partial obstruction of the bronchus

This condition may have the same causes as bronchial occlusion It may be present without any distal lung changes or it may be associated with a variety of changes on the radiograph such as evidence of lobar shrinkage without an opacity hypertranslucency due to a ball valve over inflation or evidence of distal inflammation or bronchiectasis It also often causes airlessness the x ray picture being then the same as that beyond a total occlusion Since it is not often possible to distinguish between partial or complete obstruction of the bronchus from the radiographs and since a bronchus may be intermittently occluded the term bronchostenosis is used to cover all degrees of obstruction unless complete bronchial occlusion is known to exist

Consolidation

This is a pathological term indicating the state of the lung where the alveolar air has been replaced by a cellular exudate and there is airlessness without shrinkage as in all types of pneumonia It includes replacement of the air by a transudate as in pulmonary oedema and by blood whether due to trauma inhalation or infarction It also includes replacement of the alveolar air by neoplastic cells the alveoli remaining intact a condition which occurs in some kinds of carcinoma

Difficulties arise in the use of the term because the x ray appearances are the same whatever the cause and often whatever the stage of consolidation In the earliest stages the radiograph may show patchy clouding but the shadow soon becomes homogeneous with little or no lobar shrinkage If lobar shrinkage occurs at a later date the appearances will be those of atelectasis or collapse and can be so designated

When a homogeneous shadow is seen with only slight or moderate lung shrinkage the compromise term collapse-consolidation or consolidation-collapse can be used though it is scarcely worth while since it does not indicate the most important feature namely whether or not bronchostenosis is present

Effusion

This refers to a pleural effusion whether serous purulent haemorrhagic fibrinous or transudate and includes semi solid states of any of these Fluid in other sites will be denoted with a prefix for example mediastinal extrapleural

Oval or circular shadows

These are purely descriptive terms and will cover all shadows of this shape whether the pathological lesion is believed to be an infiltration an infiltrate an exudate a productive lesion a nodule or so forth If the shadow is visible in two planes it may be styled a spherical shadow

Very small circular shadows —Synonyms—fine mottling pin point shadows This refers to shadows 2 millimetres or less in diameter

Small circular shadows —Synonyms—coarse mottling nodular shadows nodulation Shadows measuring between 2 millimetres and 2 centimetres in diameter

Large circular shadow —A shadow measuring 2 centimetres or more in diameter

Reticulation

This term is used to describe a fine linear shadowing with an interlacing pattern usually spaced 5–8 millimetres apart although a coarser pattern is possible No pathological basis directly corresponds with this network which is the result of more or less linear shadows circular shadows and small ring shadows being superimposed on each other

Honeycomb shadow or small ring shadows

Synonym—cystic lung

These are fine white ring shadows enclosing a translucent zone and measuring up to say 5 millimetres in diameter If the ring shadows are larger the condition is described as coarse honeycomb shadow

Tubular shadow

A shadow with two fine white linear walls which are more or less parallel and which enclose a central translucency about 3 8 millimetres wide

Linear or band like shadow

This is a descriptive term Linear shadows vary from hair line to 2 millimetres in thickness there are also band like shadows varying from 2 millimetres to 2 centimetres in thickness

Patchy clouding

Shadows of such an irregular shape or with such poorly defined margins that they cannot be considered circular or oval They are usually from ½ to 2 centimetres across

Ill defined opacity

Synonym—area of patchy clouding

This is a poorly demarcated or diffuse shadow

Disseminated or diffused circular shadows

Shadows which are widely disseminated more or less uniformly over a considerable area or throughout both lung fields

Bronchiectasis

The term bronchiectasis originally referred to bronchial dilatation only but is now used to include the many associated pathological changes seen either in the plain radiographs such as the opacities of a thickened bronchial wall which may actually have a narrowed lumen or in the bronchograms such as the narrowing and occlusion of the smaller bronchi as well as the dilatation of the more proximal bronchi

Bulla and bullous area

A bulla is a pathological term describing a lesion which is differentiated from a cavity by the character of its wall On a radiograph a bulla is seen as a translucent space surrounded by a thin linear zone of opacity

A bullous area refers to a translucent zone similar to a bulla but poorly demarcated from the surrounding lung There are few or no vessel markings in the translucent area and there is sometimes associated vessel narrowing in the rest of the lung

Ring shadow

Synonym—cavity

A translucent space surrounded by a zone of opacity representing its wall

Density

Unless it is qualified as number per unit area the word density will refer to the radio opacity of the lesion Judged from the radiograph this radio opacity will be relative The shadow of the heart will be as white as that of some calcified pericardium in a lightly exposed film but in a film taken with more exposure the heart will be grey and the denser more radio opaque calcified pericardium will remain white A shadow will therefore be considered dense if it remains more or less white on the radiograph while a nearby shadow of somewhat similar or larger size is grey

Low density —Small shadows caused by cells or body fluids

Fairly high density — Larger shadows—particularly those due to fluids

Dense or very high density —Shadows produced by lesions containing a lot of relatively radio opaque atoms such as iron or calcium derived from the body fluids or atoms of high atomic weight introduced from without such as iron calcium barium tin or iodine

Potter Bucky diaphragm

Synonyms—Potter Bucky Bucky moving grid

These two names have come into common use to describe a piece of apparatus the essential component of which is a grid interposed between the patient and the film with the object of absorbing some of the unwelcome scatter radiation (It is said that Bucky invented the grid and Potter made it move) It will be used as a generic term to cover any type of such grid whether moving or stationary and whatever mechanism is used for moving it during the exposure

CHAPTER 1

ANATOMICAL LANDMARKS AND VARIATIONS

A CONSIDERABLE number of errors and even a few disasters can result from the misinterpretation of shadows which are not caused by pathological conditions but by anatomical or physiological variations It is assumed that the reader is already familiar with the radiological anatomy of the thorax and only such points as are known to cause difficulties in diagnosis are mentioned below

THE DIAPHRAGM

Inspection of the diaphragm on a radiograph tends to be hurried but since it quite often gives valuable clues to the presence of a lesion it should never be perfunctory or neglected

Normally the right cupola or dome lies about ½ inch higher than the left in all phases of respiration When a discrepancy in the levels of the two domes is noted in an otherwise apparently normal radiograph an anatomical or physiological cause should first be sought Only when no such explanation seems reasonable should a more detailed radiological investigation be undertaken such as a high penetration view to exclude a shrunken lower lobe or a lateral view to exclude a tumour

Physiological Elevation of the Left Dome

It is common to find the left dome elevated because of an excess of swallowed air in the stomach At one hospital it was the custom to take the annual routine radiograph of the nursing staff immediately after a lunch which the unfortunate young women had to eat hurriedly in order to fit in the examination and also be on duty in the ward at the usual time In a high percentage of radiographs elevation of the left dome with a large gastric air bubble and fluid level was seen which was no longer seen when the nurses were subsequently radiographed at a more suitable time Children are frequently dosed with ginger beer lemonade or a cup of tea before a visit to the x ray department with the result that the same excess of gastric air is often present and is sufficient indication of the cause of any slight elevation

Elevation of the left dome from a gas distended splenic flexure is rather less common The distension may be physiological or the result of organic disease and in either case the translucency of the gas distended gut will give a clue to the probable cause of the elevation

Elevation of One Side from Spinal Curvature

In cases of severe spinal curvature the elevation of one or other dome may be considerable the cause however will be equally obvious A moderate scoliosis which may easily pass undetected unless carefully looked for (*see* p 11) may cause slight elevation of one dome—usually the dome on the convex side of the curve—and may lead to a suspicion of an underlying lung disease The normal lung vessel pattern and the presence of the curvature will generally be enough to allay suspicion

Elevation of One Side from Muscular Weakness

Muscular weakness of one dome and its consequent elevation is sometimes caused by a developmental defect but is more often acquired following damage to the phrenic nerve or to the muscle itself Damage to the nerve may arise from direct local trauma pressure from a tumour an enlarged or scarring lymph gland or the effect of a toxin Often however after full consideration of the case—sometimes even including a thoracotomy at which the thin layer of atrophic muscle is noted—there is no indication of the cause of the condition

All degrees of weakness are found ranging from that producing a slight elevation to one with extreme eventration the left dome then appearing as a thin bow line in the region of the second or *third rib* (Fig 1) In a lateral view (Fig 2) the raised diaphragm appears as an even line with a superior convex curve running from the back of the sternum to the posterior chest wall



Fig 1 — *High left dome of diaphragm* represented by a white bow line with a superior convex curve reaching to the third rib anteriorly It may have been caused by damage to the phrenic nerve in an accident 30 years previously (note ununited fracture left clavicle with wire) Much air distension of the stomach and splenic flexure beneath it Heart displaced to the right Lung hypertranslucent due to *scoliosis and shrinkage of part of a segment in the lower* zone cause unknown

Fig 2 — Same patient as Fig 1 (left lateral view) The bow line of the high left dome is marked by the arrow It extends from the sternum to the posterior margin of the chest in an even line The air-distended splenic flexure can be seen below it The right dome marked by lower arrow is peaked up anteriorly Male aged 48 years Complained of everything turning to wind Diaphragm plicated with relief of symptoms

This evenly curved line running right across the thorax will generally differentiate the condition from a hernia of the stomach passing through a moderate defect in the central part of the diaphragm in the latter case the bow line of the air distended stomach will only occupy a part of the thorax and will merge in front or behind with a more horizontal line caused by the remains of the diaphragm round the defect *Eventration must also be distinguished from the line formed by the upper margin* of herniated gut and surrounding tissue when a gross developmental defect results in the absence of most of the left dome The bow line in such cases is less well defined and the curve less even

If the elevation of one dome is considerable and on the left side it is frequently associated with a great excess of air in the stomach and colon which condition is secondary to the elevation and not the cause of it In some cases of gross elevation a barium meal is necessary to exclude a hernia Sometimes this will show that the stomach is rotated round so that the greater curvature faces upwards and lies beneath the elevated left *dome*

If the elevation is on the right side the right dome and liver will cast a homogeneous shadow in the lower half of the chest which may suggest a lower zone tumour or basal effusion (Fig 3) In a case of doubt radiographs may be taken after the induction of a small pneumoperitoneum *If the* peritoneal air extends below the right dome this will be seen as a bow line 2–3 millimetres wide with the translucent air *beneath separating it from the liver shadow (Fig 4) If on the other*

hand a tumour is present in the thorax its shadow will lie above the air translucency outlining the diaphragm Old peritoneal adhesions or poor development of these sub diaphragmatic peritoneal recesses may limit the flow of air from the site where it was introduced so that it may only outline the lower margin of the liver or spleen and not the diaphragm Careful attention to the shape of the air translucency will generally reveal the true state of affairs especially if the liver and splenic shadows are also sought



Fig 3 —High right dome of diaphragm The cause of this was a phrenic paralysis due to tuberculous glands near the right hilum The line shadow running horizontally just above it is caused by a shrunken part of the sub apical segment of the lower lobe resulting from a tuberculous stenosis of th bronchus Male aged 45 years Mass x ray findings no symptoms



Fig 4 —Same case as Fig 3 (lateral view after pneumoperitoneum and bronchography) The letter R is printed just below the shadow of the raised right dome and L below the normal left dome The upper arrow points to the band like shadow of the shrunken sub apical segment which was resected The lower arrow points to the narrow zone of air below the raised right dome

A localized elevation the result of a localized developmental or acquired weakness of one dome is not uncommon particularly in the elderly and is often neither pathological nor progressive It is most often seen on the right side and in the routine anterior view appears as a shallow localized *elevation of the normal smooth curve or as a second shadow superimposed on the main curve (Fig 5)* The innocuous nature of this shadow is usually fairly evident from inspection of the lateral view In this view the normal curve of the diaphragm can be seen extending from the posterior chest wall to well beyond the middle of the thorax after which an additional hump rises in the anterior third (Fig 6) The retrosternal position of this elevation which merges smoothly into the line of the rest of the diaphragm will serve to distinguish the condition from a cyst or tumour of the mediastinum or a small hernia Such lesions generally meet the diaphragm shadow at a much more abrupt angle (*see* p 125) A large pulmonary tumour lying in the posterior recess may give a similar appearance in the anterior view (Fig 95 p 60) but its intrapulmonary position will be at once apparent in a lateral view (Fig 96 p 60)

A 2–3 centimetre area of localized weakness of one dome may occur at sites other than the anterior third and the shadow will then more closely simulate a tumour or hernia of the liver An artificial pneumoperitoneum may be of no help since a small peritoneal fold may be carried up through a weakened piece of diaphragm with the portion of liver and the resulting air translucency will be the same whether the diaphragm is intact or whether there is an actual defect

Changes of Level with Changes of Posture

Little change in the level of the diaphragm is seen in a normal young adult whatever posture is taken up for the x ray examination On the other hand an older person or a weak ill patient tends to have a higher diaphragm shadow when lying than when standing also when the patient lies on one side that side will be considerably elevated The latter change is often seen when a lateral view is taken of a patient lying on one side (a common practice in bronchography) or in the less commonly used anterior view taken with the x ray beam horizontal and the patient lying on one side



Fig 5 —Localized elevation of the right dome (anterior view) Prominence of the diaphragm shadow is seen in the medial half below the right lung field Normal male aged 43 years



Fig 6 —Same case as Fig 5 (lateral view) Localized elevation of the right dome in the anterior half marked by arrow The condition was not progressive and did not cause any symptoms It may therefore be considered natural in an elderly adult

Tests of Diaphragm Movement

Fluoroscopy is often indicated to test the range of movement of the two sides especially when a discrepancy has been noted on the plain radiograph between the relative heights of the right and left dome In most people the range of movement is greater in the supine than in the standing position so that in a case of doubt the patient should be examined in the supine position The findings are often conflicting the two sides perhaps moving equally when the patient stands but one side showing restriction of movement when he lies down or one side may be immobile when he stands and may perhaps show paradoxical movement when he lies down or (to add to the confusion) may only show paradoxical movement when he sniffs

Interpretation is not always easy but reversal only on sniffing indicates that some functioning muscle exists but that it is unable to resist and least of all overcome the large rise in intra abdominal pressure which occurs during sniffing Sniffing is therefore a valuable test and should be tried in any doubtful case

THE NORMAL HEART SHADOW

The Symmetry of the Bony Parts

Before examining the heart shadow the bony parts should be checked for symmetry since slight rotation of the patient or a scoliosis may cause alteration in its size shape or position A gross scoliosis or gross rotation will render the anterior view radiograph of little value for the examination of the heart

The distance of the sternal end of each clavicle from the lateral edge of the vertebral body opposite or over which it lies should be noted for it will be the same each side if the patient has been radiographed in a straight position This test is easier to perform than measurement from a presumed thoracic mid line the position of which is difficult to fix or from a spinous process, which may be difficult to see Slight rotation so that the left clavicle is only ½ centimetre farther from the lateral vertebral border than the right may cause considerable apparent displacement of the heart to the left an increase in the transverse diameter, which may be as much as 1–2 centimetres and a bulge of the left border below the aortic knuckle suggestive of enlargement of the pulmonary artery (Fig 7) Even a slight thoracic scoliosis concave to the left will have a very similar effect on the image of the heart (Fig 8) so that the general alignment of the vertebral column should also be noted

It is advisable to interpose this examination for symmetry or scoliosis at an early stage and then to proceed to inspect the heart shadow hilar shadows lungs and the like and finally to return again to the bony thorax for a more detailed inspection for pathological processes This advice may seem rather elementary but adherence to this sequence may well save the patient from many fruitless examinations and consequent inconvenience and anxiety

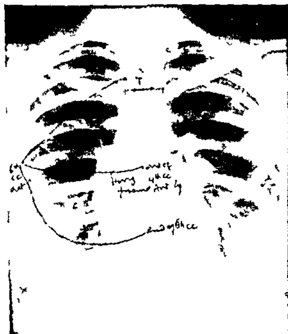


Fig 7 —Slight rotation of the patient to the left Horizontal arrow points both ways to the lateral borders of the fourth thoracic vertebra The sternal end of the left clavicle is farther from the left border than the right is from the right border indicating slight rotation to the left The lower arrow indicates a slight prominence of the left border of the central shadow just below the aortic knuckle resulting from the slight rotation The left hilar vessels are prominent from the same cause No clinical evidence of intrathoracic disease

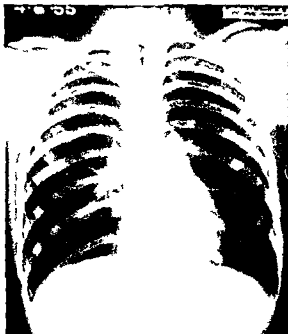


Fig 8 —Slight scoliosis concave to the left and slight rotation to the left (normal young adult) Undue *prominence of the* left heart border below the aortic knuckle Apparent displacement of the heart to the left *Left hilar vessels are* obscured and right hilar vessels appear *prominent* as they are no longer covered by the heart shadow There was some relative hypertranslucency of the left lung which cannot be reproduced A second radiograph taken with the boy straight showed none of these features

The Heart Size

The heart is best measured by its transverse diameter (T D) This can be seen in an anterior view radiograph taken with the patient sitting or standing with moderately suspended inspiration the distance of the x ray tube from the film being not less than 6 feet

There is considerable geometric enlargement of the heart shadow if a shorter tube film distance is used as may be the case on occasion for a radiograph taken in the ward for a routine anterior view in certain mass miniature radiography units or for an antero posterior view which is the usual view in bedside radiography when the patient is very ill No antero posterior view is likely to be of any use for assessing the heart size because the distance of the heart borders from the film is considerable and more or less unknown while any rotation of the patient to one side tends to enlarge the image still further

A high position of the diaphragm—whether because the radiograph was taken in expiration or because of elevation from abdominal distension as in pregnancy ascites enlarged liver spleen or any large intra abdominal tumour or particularly in babies (*see* Figs 159 and 160) and the elderly because they were radiographed lying down instead of sitting or standing—will cause the heart to lie more horizontally and thus increase the transverse diameter

Assuming none of these adverse factors is operative there is still a natural variation in the heart size of a normal person from one radiograph to another This is due to several factors such as the systole diastole difference slightly different posture (especially rotation) and different degrees of suspended inspiration In a high pressure forcibly retained inspiration (Valsalva) the heart will decrease in size during the first few beats and then enlarge Variations of size caused by this factor are probably not uncommon since the routine procedure in chest radiography is for the patient to be told to take a deep breath in and hold it in while the exposure may be made by the radiographer either almost immediately after these instructions have been carried out or not until 1–3 seconds have elapsed There may in addition be day to day variations in heart size due to the subject s activities these are probably slight however and are negligible even after violent exercise

In practice all these factors together caused a maximum variation of only 2 centimetres in only 1 out of 200 normal adult subjects radiographed 3 times at monthly or yearly intervals The variation was 1 centimetre for several others and the average variation for the whole group was only 0 5 centimetre These figures should be taken into consideration when assessing the significance of a slight change in heart size in various pathological conditions

The Shape of the Normal Heart

Normal variations in heart shape depend particularly on the habitual level of the diaphragm and the general body build The observer is usually familiar with these variations and is unlikely to be misled into considering them to be pathological It should be remembered however that the narrow vertical flask shaped heart tends to be centrally placed whilst the larger more horizontal type which has a relative prominence of the left border lies with two thirds of the shadow to the left of the mid line and one third to the right Therefore if a relatively large but apparently normal heart is placed centrally this would suggest displacement of the heart to the right and would not suggest a pathological enlargement of a narrow vertical centrally placed heart The latter rarely enlarges evenly on both sides but usually only to the left and would therefore no longer remain centrally placed and flask shaped with right and left borders similar in outline and equidistant from the mid line

Occasionally the main trunk or both the main trunk and the left branch of the pulmonary artery are unduly large resulting in a prominence of the left border of the central shadow just below the aortic knuckle In the absence of any clinical evidence of an abnormality such an x ray appearance should be considered a normal variation It is sometimes necessary to prove by fluoroscopy tomography or kymography that the prominence is caused by the artery and not by a tumour

An unduly high position of the aortic arch and therefore a high and prominent aortic knuckle may also be mistaken for a tumour until one of the foregoing simple tests reveals its nature (Fig 9) Cardiac catheterization or angiocardiography are rarely indicated in these cases from the x ray appearances alone especially if the possibility is borne in mind that the explanation of the shadow is an anatomical variation

Slight asymmetry or scoliosis will produce slight variations in shape with a tendency to prominence of the left border below the aortic knuckle (*see* Symmetry of the Bony Parts p 11)

The Position of the Heart in a Normal Person

In a normal person without any pulmonary lesion the heart shadow sometimes appears to be displaced on the radiograph This is commonly due to unnoticed or uncorrectable rotation of the patient as he stands opposite the cassette or to thoracic cage asymmetry particularly that associated with a scoliosis These factors should be considered first as a possible cause for a displaced heart shadow (by inspection of the bony parts for symmetry *see* p 11) before a pulmonary lesion is suspected as a cause of the displacement In babies even a very slight rotation is associated with considerable movement of the mediastinal contents to one side or the other



Fig 9—High aortic knuckle Shadow in the medial third of the left upper zone found originally on mass miniature radiography and considered to be caused by a tumour The kymogram shows no aortic pulsations independent of the shadow and oblique views and tomograms also indicated that the shadow was caused by an abnormally high position of an otherwise normal aorta No symptoms or abnormal physical signs

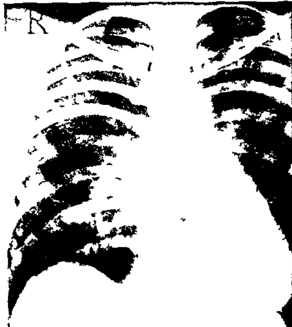


Fig 10—Heart displaced to the left This was due to a depressed sternum which was obvious both on clinical examination and in a lateral view radiograph *The right* hilum is bared by the displaced heart and therefore appears prominent There is a slight relative translucency of the left lung and the lung vessels appear rather narrower than on the right features which could not be clearly reproduced

Kyphosis or a depressed sternum are usually obvious on clinical examination but if they are forgotten as a possible cause for a displaced heart at the time the radiograph is inspected they will be obvious when a lateral view is taken A depressed sternum usually causes displacement of the heart to the left (Fig 10) although the heart may be occasionally pushed to the right

Mirror transposition may be mistaken for a heart displaced to the right but usually the aortic knuckle is also transposed or the gastric air bubble is noted under the right dome

When anterior view radiographs are taken in special circumstances with the x ray beam horizontal and the patient lying on one side the heart is displaced towards the lower side to a variable degree

Whatever the cause of an apparent displacement or a real though normal displacement may be it will result in the hilar vessels on the opposite side being less covered by the heart shadow and thus appearing unduly prominent This often results in a fruitless search for a neoplasm which may cause the patient much anxiety Hence the need for careful consideration of these factors

NORMAL TRACHEAL TRANSLUCENCY

The position of the tracheal translucency should next be noted Normally it lies centrally but with a slight bias of the lower third towards the right Its position must be assessed in relation to the orientation of the patient (indicated by the position of the sternal ends of the clavicles in relation to the vertebral body over or opposite which they lie) and the presence or absence of any scoliosis Rotation of the patient so that the left clavicle is displaced only 2–3 millimetres to the left in relation to the vertebral shadow or a mild scoliosis concave to the left will result in displacement of the tracheal translucency to the left Rotation of the patient the other way or a scoliosis concave to the right will result in an even greater apparent displacement of the tracheal translucency to the right

If there is an actual displacement of the trachea to the right due to some pathological cause and if in addition there is some rotation of the patient to the left when he is radiographed then the two factors may balance and the trachea appear to be central In such a case the real tracheal deviation to the right will be detected in spite of its apparent central position if the orientation of the clavicles is noted

THE HILAR OR ROOT SHADOWS

The hilar shadows in a normal subject are produced by the main and lobar branches of the pulmonary arteries and veins a feature which is well shown in tomograms The right and left main bronchi may show as tubular translucencies with 1 millimetre wide faintly opaque walls they are however in conspicuous in the plain anterior view radiograph The size of the vascular component of the hilar shadows is very variable even in normal subjects so that only a considerable increase or decrease in the size or number of these arborizing shadows can be considered pathological Apparent enlargement of one side may be seen in a normal person if the heart is displaced (for example by a scoliosis) when the absence of the cover of the heart shadow makes the hilar vessel shadows unduly conspicuous

The centres of the hilar shadows are roughly at the same level but, as the top of the left main pulmonary artery is higher than the right the left hilar shadow may appear as much as ¼ inch the higher of the two Either side may be drawn upwards for as much as 1–2 inches by a pathological contracting lung lesion

In a normal person the upper lobe and lower lobe groups of vessels can be clearly identified Together with the main artery and vein they produce a shadow shaped like a Y lying on its side thus ≻ (*see* Figs 13 and 68 p 46) Failure to see this will suggest that one or other groups is pathologically displaced as in a lobar collapse or atelectasis or has been removed in a lobectomy

Not only is the left main branch of the pulmonary artery higher than the right but it is more conspicuous and this natural tendency to prominence of the upper part of the left hilum may be mistaken for a pathological enlargement or may hide a pathological shadow lying medially behind the hilum

Pathological enlargement of the hilum shadow will be suggested if any shadow is seen in the area which is not obviously continuous with one or other of the vessel markings When there is any doubt as to whether all the shadows seen are vascular or whether there is an additional pathological shadow a lateral view should be taken and if necessary tomograms (*see* p 157)

THE LUNG FIELDS

Before a detailed search for pathological shadows is begun the lung fields should be inspected as a whole and the translucency of the two sides noted and compared particular attention being paid to the costo phrenic recesses The vessel pattern should be carefully inspected and compared on the two sides and the line of the horizontal fissure sought The presence or absence should be noted of certain parts of the thoracic coverings which may at times cast shadows over the lung fields such as the scapulae breasts nipples and costal cartilages

THE RADIOTRANSLUCENCY OR BLACKENING OF THE LUNG FIELDS

The radiotranslucency or blackening of the two sides is the same at the same level in normal people provided they are positioned straight If they are rotated so that the clavicles are slightly to the left or if there is a scoliosis concave to the left the left side will appear rather more translucent or darker than the right Rotation or scoliosis the other way will result in the right side being the darker side

Developmental asymmetry of the thorax may also result in hypertranslucency of one side The asymmetry can be detected by inspection of the rib or soft tissue shadows

The Pulmonary Vessel Pattern

The pulmonary vessel pattern constituting the lung markings is of great importance in diagnosis It should be traced out from the hilum on each side The size of the vessels as well as the number in a given area (the density) should be compared on the two sides after the early division they will normally be found to be much the same An exception to this will be found in the lower zones near the heart where there is a richer pattern on the right side since the vessels on the left are displaced and obscured by the prominence of the heart shadow

In the anterior view radiograph the close proximity of the larger vessels in the medial segment of the middle lobe together with those of the cardiac segment often results in such a rich pattern that the shadows may be considered pathological When this type of vascular pattern is seen in the right lower zone and there is doubt whether it is significant a lateral view radiograph should be taken which in a normal person will show a normal vessel pattern and confirm the absence of any abnormal shadows It should be noted that in a normal person such a rich vascular pattern will remain unchanged in serial radiographs taken over a period of years thus confirming its non pathological basis

The vessel pattern should also be traced upwards towards the apices In a normal person vessel shadows can be seen extending up to and often well above the clavicles Failure to see them in one apex might be the first indication of a small bulla or pneumothorax The horizontal branches normally lying either side of the horizontal fissure on the right side may act as a guide to seeing a rather indistinct fissure or fix its probable position should it be invisible

A conspicuous horizontal branch which supplies either the lateral part of the lingula or the apical lower lobe segment and which is normally seen extending out from the left hilum should also be identified It will slope downwards if there is collapse of the lower lobe the shadow of which may be hidden by the heart shadow

The Costo-Phrenic and Cardio-Phrenic Angles

The costo phrenic angles should be acute clear and symmetrical in translucency If the diaphragm is abnormally low in position as in some normal persons in asthma even before the onset of emphysema and in emphysema the costo phrenic angles may be obliterated the extreme axillary portion of the muscle failing to descend as far as the rest of the diaphragm In fact this relatively high costal attachment may result in the angle becoming obtuse (Fig 11) and may simulate a small pleural effusion In case of doubt a lateral view will confirm the general flattening of the diaphragm and show that there is no additional shadow in the posterior recess such as would be seen with a pleural effusion

The cardio phrenic angles are normally acute but that on the left is frequently obscured by a low density triangular shadow in elderly fat people due to fat near the apex of the heart (Fig 12) In some cases it may be necessary to take an additional anterior view radiograph with greater exposure in order to define the left border of the heart more clearly through the shadow of the pad of fat It will then be possible to measure the transverse diameter more accurately or to make sure that the well defined lateral border of the pad of fat is not caused by the shadow of a collapsed lower lobe

The Horizontal Fissure

The horizontal fissure is visible in a routine anterior view radiograph in over 80 per cent of normal adults It is seen as a white hair line shadow running from roughly the centre of the right hilum to meet the sixth rib in the axilla Although in most cases it can be seen quite clearly in some it is seen most convincingly with the aid of a magnifying glass It is absent or very incomplete in about 10 per cent of people and may be invisible in the radiograph even if it is present in very obese subjects or in a somewhat under exposed radiograph particularly if it is covered by a rib shadow Although it usually runs straight across the lung field it may even in normal persons slope upwards or downwards at a small angle or curve downwards towards the outer third A downward inclination is frequent in elderly persons with a kyphosis Care must be taken in such cases to ensure it is not displaced as a result of shrinkage of a lobe

Another normal hair line shadow is sometimes seen *running downwards* and outwards to meet the diaphragm about 1 centimetre lateral to the right border of the heart This line is not caused by an accessory lobe or fissure and is probably a part of the main fissure between the middle and lower lobes

THE ACCESSORY LOBE OF THE AZYGOS VEIN

A hair line usually with a slight lateral convex curve (Fig 13) is sometimes seen running down across the right apex to end in a comma like expansion near the hilum This is the fold of pleura demarcating the so called accessory lobe of the azygos vein It is not in itself pathological nor is the part of the right apex thus cut off unduly liable to disease



Fig 11 —Obtuse right costo-phrenic recess resulting from the low position of the diaphragm on full inspiration This appearance is seen particularly in patients with asthma *asthma and emphysema or chronic bronchitis and* emphysema It may be present in a patient with no symptoms nor abnormal physical sign

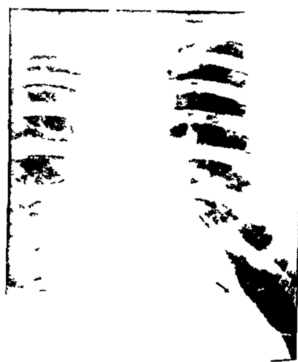


Fig 12 —Pad of fat obscuring the apex of the heart and producing a straight left border (rather obese male aged 45 years) The left border of the heart is visible as a faint *shadow 1 centimetre medially to the edge of the shadow* of the pad of fat (*see* arrow)

This line may lie medially about 1 centimetre from the vertebral margin or extend almost laterally to meet the chest wall just below the clavicle Most frequently it lies somewhere between these two positions The comma like shadow at its termination near the hilum can always be seen either on the plain radiograph or if it is not clear on this on a tomograph

THE SCAPULAE

Sundry extrathoracic structures such as the scapulae breasts nipples or muscles may cast shadows which are superimposed on the lung fields of a normal subject and these must be recognized and differentiated from shadows caused by intrapulmonary pathological conditions

The vertebral borders of one or both scapulae may be partly superimposed on the lung field either because of a faulty technique in positioning the patient or because of their unavoidable relative fixity Systematic identification of the scapular shadows will avoid errors of interpretation from this cause

THE BREAST SHADOWS

The breast shadows should be identified where possible This is usually easy the shadows being obvious but in the case of a thin elderly woman with fibrotic atrophic breasts the unusual homogeneous shadow seen in the lower axillary regions may cause difficulties Its true nature will be appreciated if it can be traced passing off the lung field to merge with the shadow of the lower axillary fold (Fig 14)

If one breast is the seat of disease has been removed or is larger or lower than the other a localized area of opacity or hypertranslucency may be seen at one base In a case of doubt a radiograph taken with the patient lying down may be decisive if the breasts are small and flat or very large insufficient displacement of the shadow may result from this manoeuvre and a lateral view will be needed to prove the shadow extrathoracic If the breasts are large and dependent the lateral view may also be obscure

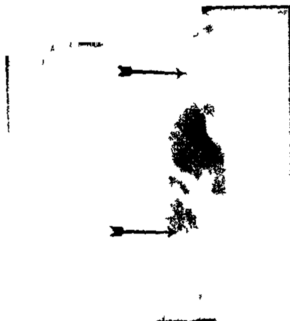


Fig 13—Accessory lobe of the azygos vein (tomogram of right upper zone posterior view) The fold of parietal and visceral pleura cutting off a part of the upper lobe can be seen as a thin line with a lateral convex curve opposite the upper arrow The comma like shadow of the vein is seen at the lower end of this line in the angle between the right main and upper lobe bronchus The lower arrow points to the ≻ shaped shadow of the normal hilar vessels the stalk of the Y being rather indistinct in this case

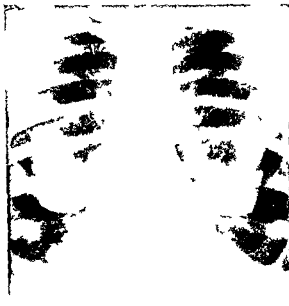


Fig 14—Unusual mammary shadow on either side Anterior view radiograph of the chest of a female of 66 years The well-demarcated concave lateral border of the shadow could be traced upwards and outwards beyond the ribs The diaphragm is low and flattened and the heart centrally placed The hilar vessels are large but the lung vessels small The rather hypertranslucent lung field are due partly to the thin covering of the patient

unless a flannel band is bound round the chest in order to displace the breasts forward and medially and if possible clear of the lung fields or unless the radiograph is taken with the patient lying down Even after these precautions a tomogram may sometimes be necessary to make sure that a basal shadow low down anteriorly is only the breast shadow or that the breast shadow is not masking an intrathoracic shadow

THE NIPPLES

If the nipples show at all on the radiograph both are usually visible as ½–1 centimetre circular shadows so that identification is easy In some cases however one nipple may be much more distinct than the other especially if the shadow on one side lies in an intercostal space whilst that on the other is superimposed on a rib Differentiation from an intrapulmonary shadow may then be necessary and for

this the simplest procedure should be chosen which will serve the purpose If the breast is fairly large a film with the patient supine will result in lateral displacement of the nipple which will often fall clear of the lung field If the breast is small and flat displacement will not be possible but a radio-opaque marker such as a piece of fuse wire placed round the nipple will show whether the nipple and the shadow do in fact correspond Another method is to take a pair of radiographs the first in inspiration and the second in expiration The nipple will then be seen farther up in the former than in the latter whereas a lower third intrapulmonary shadow would be farther down during inspiration than during expiration If there is still doubt and if the shadow is too small to be seen in a lateral view a tomogram may be necessary

The Muscles of the Chest Wall

The muscles of the chest wall usually cast some shadow over the lung fields particularly those forming the lower folds of the axillae and those passing vertically downwards in front of the apices The nature of these shadows usually becomes obvious when they are traced out beyond the lung fields This test should therefore be always applied when a doubtful shadow is seen

Slight asymmetry of the pectoral muscles on the two sides may result in a faint haze over the outer half of one mid zone One muscle may be thicker than the other if it is hypertrophied because of being used more—perhaps during some occupational manoeuvre or in some left handed people More often one side is more radio opaque because a slight scoliosis or slight rotation of the patient causes the bulk of the muscle over the mid zones to be different on the two sides As a rule loss of translucency caused by this factor is very poorly demarcated but sometimes the lower margin of the shadow can be traced laterally as a well-defined line passing off the lung field to merge into the shadow of the lower axillary fold with its typical inferior concave curve If it is very poorly defined and there is no evidence of rotation or scoliosis a lateral view may be needed to distinguish it from the shadow caused by an area of consolidation

Occasionally atrophy or a developmental defect of the pectoralis major or some other group may cause the lung field beneath to appear unduly translucent Clinical inspection would of course then show the cause quite easily

The sternomastoid and scalenus anticus show the familiar low-density shadow with a well-defined lateral margin passing down the medial third of the apex They are frequently not quite symmetrical They meet another low-density shadow running just above the clavicles one of the so-called companion shadows (*see* p 19)

None of these muscle shadows is often mistaken for a pathological lesion but now and again an apical view or even a tomogram may be necessary to make quite sure of the innocent nature of the shadow

The Subclavian Artery

In some adults the left subclavian artery and surrounding tissues may cause a well-defined 3-5 millimetre wide band like shadow to be seen passing horizontally in front of the left apex with an inferior concave curve Medially this band like shadow may disappear as it reaches the central vascular shadows but sometimes the inferior border can be seen curving round becoming more obviously continuous with the lateral border of the central shadow and finally passing downwards to meet the aortic knuckle Enlargement or lateral displacement of the proximal part of the artery (as in co-arctation of the aorta) makes this merging with the lateral upper border of the central shadow more conspicuous Laterally the artery shadow disappears when it reaches the edge of the lung translucency

Sometimes the subclavian artery lies higher so that no translucent area of lung can be seen above it and its upper margin merges into the general haze of the lower neck region In such cases the shadow with its inferior concave margin will simulate a cap of thickened pleura over the apex Differentiation is made possible by the fact that the pleural shadow would extend a short way down the axilla whilst the shadow of the artery ends abruptly when it meets the axilla as it passes horizontally

Often only a part of the artery shadow can be seen where the density of the artery is reinforced by the faint shadow of the sterno-mastoid and scalenus anticus muscles This combination may simulate a pathological shadow in the apex The abrupt ending at the margin of the muscle or a faint

lateral extension of the shadow beyond this usually gives the identification but sometimes an apical view or tomogram may be necessary to exclude an abnormality

The Companion Shadows

A 2-3 millimetre wide companion shadow is often seen running parallel to the upper border of the clavicle It is caused by the fold of skin and subcutaneous tissue lying rather horizontally above the bone so that a considerable thickness of tissue meets the x ray beam horizontally It is often symmetrical on the two sides and can generally be traced laterally beyond the margins of the translucent lung fields (Fig 15) if one clavicle is relatively elevated however the companion shadow may be more conspicuous on one side It may also be denser where it is reinforced by the shadow of the sterno mastoid and if there is an abnormal vertical linear shadow in the apex as well the companion shadow meeting this may be mistaken for the lower margin of a cavity

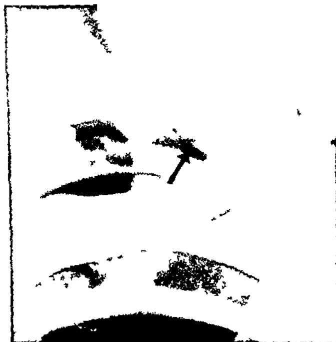


Fig 15 —Companion shadow seen as a line running parallel to the left second rib (opposite arrow) A 3 millimetre wide companion shadow is also visible running parallel with the upper border of the clavicle Similar shadows were seen on the right side Normal adult male



Fig 16 —Companion shadow seen as a line running parallel to the chest wall just above the right costo-phrenic recess (marked by arrow) In the original radiograph a faint haze could be traced from the line continuous with the extrathoracic soft tissues while a similar line was visible above the left costo-phrenic recess Normal rather thin adult female

A second faint 1 2 millimetre wide companion shadow is often seen running parallel to the infero-medial concave surface of the second rib in the axilla (Fig 15) It looks like an area of pleural thickening but is due to extrapulmonary soft tissues and normal pleura made visible because of the tangential direction of the x rays in relation to them It is usually symmetrical on both sides

A third companion shadow is sometimes seen in very thin subjects due to the thoracic coverings over the lower chest casting a 1-2 millimetre wide shadow in the lower axilla close to the ribs extending up for 1 2 centimetres from the costo phrenic recess (Fig 16) It is usually bilateral but may be more conspicuous on one side if the patient is not orientated straight It closely simulates the shadow of a thickened pleura or a very small lower axillary pleural effusion but it can generally be differentiated from these because of its more obvious continuity with the shadowing which lies beyond the ribs

laterally. In a case of doubt a lateral view may be necessary to show that the posterior recess is clear, thus excluding a small effusion.

The Sternum

The edge of the manubrium of the sternum is frequently visible just below the sternal ends of the clavicles. If there is slight rotation of the patient one border of this shadow may be very conspicuous (Fig. 17) and may even suggest the presence of a mediastinal tumour. To avoid misinterpretation it is usually enough to bear in mind the possibility that the shadow may be that of the sternum. Its identity will be confirmed if the lateral border can be traced up as a continuous line into the white line of the articular cortex of the joint with its superior concave curve.



Fig. 17.—Prominent upper right border of the sternum simulating an abnormal mediastinal shadow (marked by arrow). This was caused by slight rotation of the patient to the right.



Fig. 18.—Bifurcated rib simulating a pulmonary cavity. Arrow points to the circular translucency surrounded by bone. Right basal pleural thickening also present with flattening of the right dome of the diaphragm.

The Costal Cartilages and Ribs

Calcification of the costal cartilages is common even in normal young adults and some calcification is almost inevitable in the elderly. The first costal cartilages are nearly always calcified after the age of 25 years. The calcification is generally rather irregular, giving a series of circular or mottled shadows, and there is often one area which appears as a small pointed extension of the inferior margin of the rib shadow.

These shadows are not symmetrical and the pattern varies with different people, so that they form useful identity checks when ensuring that a pair of comparative radiographs are in fact of the same patient.

Shadows of the costal cartilages should be sought and their nature appreciated when inspecting the lung field for normal variations. They are then unlikely to be mistaken for pathological intrapulmonary foci but, as in the case of a rib shadow, there is always the possibility that they cover and hide a small abnormal lung shadow. If both cartilage and abnormal focus shadows are present, and are close but not superimposed, it is easy to misinterpret the abnormal focus as belonging to the group of nearby

mottled shadows of calcified cartilage especially if the latter are not very radio opaque Tomograms may be indicated in some cases to prove or exclude an underlying lung focus

Developmental abnormalities of the ribs are common but rarely result in shadows which might be mistaken for pathological lesions Part of a small cervical rib may be mistaken for an apical lesion and the circular translucency sometimes seen between the end of a bifurcated rib or pair of fused ribs may simulate a cavity (Fig 18) Careful inspection of the bony parts which should be a routine will usually be sufficient to avoid mistakes of this kind

The Vertebral Column

An isolated long transverse process of a mid thoracic vertebra may suggest a fluid level in a cavity especially when it is superimposed on the mesh of the hilar vessels Failure to find the lesion in a justifiably taken lateral view will be an indication for a high penetration anterior view or for fluoroscopy when the true state of affairs will be clearly seen

If there is a scoliosis the edge of the vertebral column on one side will sometimes be visible in the lower part of the chest and may be mistaken for a lesion such as the edge of a collapsed lower lobe or even a tumour This mistake should be avoided if the visible part of the vertebral column is inspected at the same time as the ribs

Plaits of Hair Clothing Skin Tumours and Subcutaneous Tumours

Plaits of hair and even gowns and other clothing occasionally cast confusing shadows over the upper third of the lungs Their true nature is usually evident when they can be traced beyond the limits of the thorax

Skin nodules such as a mole a benign tumour or a cystic swelling may cast circular shadows over the lung Clinical inspection will often reveal their identity otherwise their extrathoracic position may not be noted until a tomogram is taken

CHAPTER 2

HOMOGENEOUS SHADOWS GROUPED ACCORDING TO SHAPE, SIZE, OR DISTRIBUTION

UNILATERAL TOTAL HOMOGENEOUS OPACITY

THE CAUSE of total opacity of one side of the chest may be obvious from the clinical picture and physical signs but this is not always the case On the radiograph the position of the heart and trachea should be observed with particular care since the patient is usually quite ill and correct positioning is difficult Displacements must therefore be assessed in relation to the appearance of the bony parts

Gross displacement to the other side (that is away from the opacity) indicates a massive pleural effusion (Fig 19) whilst displacement to the same side (Fig 20) indicates shrinkage of the lung with airlessness which is often associated with stenosis and effective occlusion of the main bronchus If the lesion is on the left side the air in the stomach will outline the left dome of the diaphragm which will be considerably raised (Fig 20)

Acute total pneumonic consolidation on one side is rarely seen nowadays but if it is seen there is either no displacement of the heart and trachea or else only slight displacement towards the opaque side (Fig 21) This feature can rarely be demonstrated with certainty because the patient is usually too ill to be positioned straight

A hydropneumothorax or haemopneumothorax if the radiograph is taken with the patient supine gives a similar picture to that of a massive effusion except that the displacement of the heart and trachea may be less marked The clinical picture is usually such that steps to demonstrate the fluid level for purely diagnostic purposes are unnecessary If the patient cannot sit up or turn on his side (for example because of other traumatic lesions) the fluid level can still be demonstrated in a lateral view taken with a horizontal x ray beam

Sometimes an original radiograph of a patient shows the x ray appearances of stenosis with effective occlusion of the main bronchus (similar to those seen in Fig 20) whilst a subsequent radiograph (Fig 22) shows the same homogeneous opacity but with the trachea now central and the heart no longer displaced or even both displaced to the opposite side This indicates the combination of an effusion and occlusion of the main bronchus in which the shadow of the opaque lung and the fluid cannot be separately distinguished

When extensive consolidation is present the development of a small or moderate effusion cannot be detected even on a well exposed radiograph unless some aerated lung is present lying between the two shadows or unless the consolidation begins to resolve when the homogeneous shadow of the fluid usually in the region of the costo diaphragmatic recess will be seen in contrast to the more patchy clouding in the lung

LARGE HOMOGENEOUS SHADOWS OCCUPYING ONLY A PART OF ONE SIDE

A large homogeneous shadow occupying only a part of one lung field may be due to a great variety of causes When such a shadow is seen for the first time in an anterior view radiograph it is usually necessary to take a lateral view to establish its size shape and position It is also necessary to determine possibly with the help of further radiological investigations whether the shadow represents a pleural mediastinal or intrapulmonary lesion Distinction between these may be easy or it may be very difficult and at times impossible Special attention should be given to the position of the shadow its relation to nearby normal shadows particularly the cardio vascular and skeletal shadows the presence or absence of any displacement of the normal vessels and fissures and the appearance of the major bronchial translucencies on tomography A barium swallow may be necessary to show its



Fig 19—Massive left pleural effusion. Heart and trachea displaced to the right. Tuberculous infection of the lung. Tubercle bacilli in the fluid on aspiration

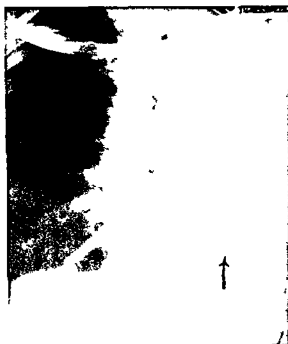


Fig 20—Atelectasis of the left lung from stenosis of the left main bronchus. Heart and trachea displaced to the left. Arrow points to the gas cap which marks the position of the raised left dome



Fig 21—Pneumonic consolidation of the left lung from pneumococcal infection. No tracheal displacement. Elderly male. Complete resolution



Fig 22—Atelectasis of the right lung from stenosis of the right main bronchus complicated by large right pleural effusion. A month previously the trachea was to the right and is now to the left

relation to the oesophagus and it may even be necessary to outline the *major vessels by angiocardio*graphy

PLEURAL SHADOWS

A pleural effusion gives a homogeneous shadow the site of which depends on whether it is free or encysted. The shadow can usually be distinguished from one caused by an intrapulmonary lesion by the anatomical site by the character of *its fairly well defined margins particularly* when considered in relation to the situation of the shadow by the position of the nearby fissure which may be visible and which will not be displaced or by the absence of any alteration in the pattern of the main blood vessels. *The main bronchial translucencies will also appear normal should they be demonstrated in* tomograms. These criteria are valid even if some air is also present in the pleural space resulting in *a horizontal fluid level* demarcating the upper part of the opacity when the patient is radiographed *in the upright position or lying* with the x ray beam *horizontal*

In some cases it may not be possible to distinguish the x ray shadow of a pleural effusion encysted medially adjacent to the heart shadow from the shadow of a mediastinal neoplasm a mediastinal effusion or even an aortic aneurysm

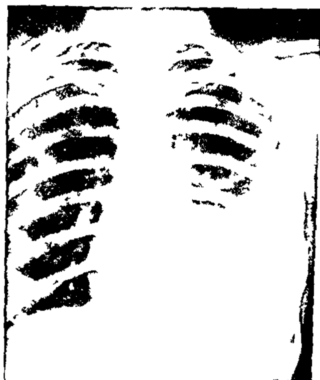


Fig 23 —Moderate sized left pleural effusion. The poorly defined superior concave margin is seen but no apparent displacement of the heart or trachea. The position of the sternal ends of the clavicles indicate slight rotation of the patient to the left *so there is in fact slight displacement of* the heart and trachea to the right



Fig 24 —Same case *(lateral view)* *The dark radio translucent* retrosternal region in the upper half contrasts with the grey opacity of the lower half caused by the fluid. Arrow points to the line of the thickened interlobar pleura which is only visible in the upper third. Idiopathic lymphocytic effusion in female aged 23 years

The character of the fluid cannot be determined from the radiographs nor in fact when it is encysted can it be determined from them whether it is still fluid or whether it *has become semi solid or even* solid and fibrous as a result of the organization of the cellular exudate

Moderate sized free pleural effusion

A moderate sized free pleural effusion casts a characteristic homogeneous shadow. This lies *in the* lower part of the lung field it is of much the same radio-opacity as the heart shadow and reaches its *highest level in the axilla* from which *point* its poorly defined upper margin runs medially towards the heart shadow with a superior concave curvature (Fig 23). If the diaphragm is visible it is seen

to be slightly raised There may be some displacement of the heart and trachea to the other side but *this feature cannot be demonstrated with any certainty if the patient is slightly rotated as is often* the case with a sick subject The effusion usually shows little change of position with changes of posture but if it is of very recent origin it may shift with greater ease

The diagnosis of a moderate pleural effusion is usually obvious as a result of the clinical examination so that the radiograph is as a rule taken only to show the extent and position of the fluid and the presence or absence of any underlying abnormal lung shadows

If there is any doubt about the clinical or x ray diagnosis a lateral view should be taken which is often characteristic (Fig 24) At a superficial glance the opacity is very difficult to see at all but more careful inspection will show that the retrocardiac area is grey compared to the darker retrosternal translucency lying just above the heart shadow Normally the blackening of these two areas is much the same so it will be obvious from this test that there is a general basal haze The poorly defined upper margin of this faint area of clouding runs with a superior concave curvature from the back of the chest to the retrosternal region and has a peak towards the middle thus producing a double



Fig 25 —Small left pleural effusion The costophrenic angle is opaque and a shadow with a well-defined vertical margin extends up the axilla for about 3 centimetre thinning to a line shadow at the upper end Restriction of movement of the left dome



Fig 26 —Small left pleural effusion (lateral view) Small arrow marks the antero-superior edge of the shadow of the fluid occupying the posterior costo phrenic recess Note how opaque this is in comparison with the dark and translucent retrosternal region above the heart shadow Vertical arrow marks left dome

curve A second peak will be seen anterior to this situated some 2 inches behind the sternum and with its apex pointing upwards and posteriorly if there is some extension of the fluid into the interlobar fissure A thin line due to thickened interlobar pleura will often be seen extending upwards beyond the apex of the shadow

Small pleural effusion

A small pleural effusion may be difficult to detect on clinical examination and the diagnosis will be dependent on the radiographs In the routine anterior view radiograph the diaphragm may appear to be normal in position but may show some restriction of movement on the affected side on fluoroscopy This restriction is not usually great enough to cause sufficient difference in the low

between the right and left domes for the condition to be detected in the routine radiograph taken with the breath held at the end of a moderately deep inspiration

The upper border of even a small effusion can generally be detected as a small homogeneous area of clouding occluding the costo phrenic recess (Fig 25) This has a better defined upper margin usually with a slight concavity *facing towards the hilum* than would be seen in the case of a somewhat simil opacity caused by a small area of pulmonary consolidation occurring in this peripheral situation Inferiorly the shadow occludes the recess and merges with a normal diaphragm shadow in contra distinction to the occlusion of the recess which is sometimes seen when the diaphragm is low and flat (Fig 11)

Sometimes the recess itself is clear but an effusion may be suspected if a 1–2 millimetre linear shadow due to thickened pleura is seen extending up the axillary edge of the chest for perhaps 1 centimetr (Fig 25) The linear shadow due to thickened pleura must not be confused with the soft tissu companion shadow which is occasionally seen in very thin subjects (*see* p 19 and Fig 16) In the case of a companion shadow the costo phrenic recess remains acute and clear and the shadow can generally be seen to be symmetrical on the two sides though if the patient is slightly rotated it may be more distinct on one side than the other



Fig 27 – Encysted left axillary effusion The well-demarcated medial convex border is visible in the upper half The shadow of the encysted effusion merges below with the shadow of a consolidated lower lobe and a peripheral *basal pleural* effusion



Fig 28 —Extrapleural effusion in the upper right axillary region Arrow points to the well marked medial convex border of the shadow The effusion was extrapleural and *arose from an* infected gland in the chest wall It displaced the pleura and nearby lung medially

If there is any doubt as to the cause of the shadow *or if the anterior* view is quite normal *but* a small effusion is suspected then a lateral view should be taken In this even a small effusion will cast a shadow which will occupy the posterior costo-diaphragmatic angle and end with a fairly well defined slightly concave margin facing towards the hilum (Fig 26) This is probably the most delicate test for the presence of a small effusion although in the early stages before it is limited *by adhesions* it may also be detected as a fine band like axillary *shadow* in an anterior view radiograph taken with th patient lying on the affected side with the x ray beam horizontal

Axillary encysted pleural effusion

When an effusion is encysted in an axillary position the shadow will lie against the chest wall and have a medial convex margin which is generally very well defined (Fig 27) If it is large or the late complication of a once generalized pleural effusion the shadow may show an extension downwards to the costo phrenic recess which will then be occluded—thus indicating the pleural nature of the shadow If on the other hand it is small and high up and the general effusion from which it arose has absorbed or if it was always a localized effusion then the diagnosis as to the nature of the shadow may be uncertain since a similar shadow may be seen with an extrapleural effusion such as may occur secondary to an inflammatory lesion of a rib or from breaking down lymphatic glands in the chest wall (Fig 28) A similar shadow will also be seen with pleural or extrapleural secondary deposits which may be single or multiple or more rarely with a benign tumour such as a peripherally situated neurofibroma

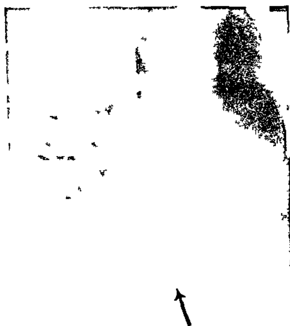


Fig 29—Interlobar pleural effusion (lateral view) Arrow points to the right dome of the diaphragm Spindle shaped shadow passes upwards and backward from this in the line of the main fissure with a forward extension of the shadow into the horizontal fissure Opacity of the posterior recess is caused by a free pleural effusion which is also present *Idiopathic tuberculous effusion*

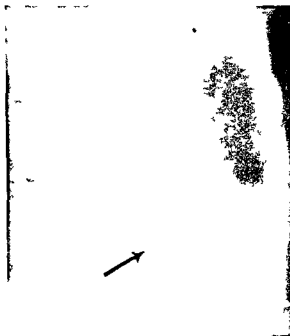


Fig 30—Interlobar effusion into horizontal fissure only (lateral view) Arrow points to a line shadow caused by some thickening of the main interlobar fissure which meets the right dome 1½ inches behind the sternum The spindle shaped shadow is superimposed on the line shadow of the thickened horizontal fissure along the edge of the effusion *It was just as clearly demarcated in the anterior view*

Interlobar pleural effusion

An interlobar pleural effusion is not very common except as an extension of a general peripheral effusion It results in a rather characteristic spindle shaped or sausage shaped homogeneous shadow with well demarcated margins lying with its central axis in the expected position of one of the interlobar fissures

In an anterior view the shadow will be particularly well demarcated if it lies in the region of the horizontal fissure when it will meet the sixth right rib in the axilla If it lies only in some part of the main fissure the shadow will be less well defined in this view but will be very clearly defined in a lateral view (Fig 29) In this view the shadow may be seen to lie anywhere along the course of the main fissure which can be indicated by a line drawn from the postero-inferior angle of the body of the fourth thoracic vertebra extending downwards and forwards to meet the diaphragm 1–1½ inches behind the sternum Sometimes the effusion is confined to the horizontal fissure in which case it will lie along a line drawn horizontally forwards from the main fissure starting just below the tracheal translucency

and reaching to the sternum (Fig 30) It may extend into both fissures as illustrated in Fig 29 and may be associated with some shadowing from fluid in the more peripheral part of the pleural cavity If it is situated at the upper *posterior end of the* main fissure only the lower end of the shadow will be spindle shaped since the upper end will lie against the main pleural cavity and posterior chest wall If it lies at the lower *extremity of the main fissure* only the upper end will taper and be drawn out into a thin line whilst the lower end will widen out into a triangular shadow with its base merging into the shadow of the diaphragm (Fig 34)

Generally there is a thin linear extension beyond the shadow of the effusion at one or both ends due to a continuation of the pleural thickening along the line of the fissure a feature which may be seen *most clearly in lateral* view tomograms These will also confirm that the vessel pattern in the nearby lung is normal a feature which will distinguish the shadow from that of an atelectatic shrunken middle lobe

A neoplastic mass adjacent to an interlobar fissure may transgress the pleural boundary and produce an oval shadow with a convex bulge either side of the predicted fissure line it will then be indistinguishable from the shadow of an interlobar effusion More often the shadow of a neoplasm is rather more circular or lobulated and rather less well demarcated than that of an interlobar effusion

Anteriorly encysted pleural effusion

An anteriorly encysted pleural effusion tends to lie rather medially so that its shadow may merge with that of the heart In a lateral view it will be seen to lie behind the sternum and it usually has a well defined margin which is posteriorly convex if the effusion is relatively high up or posteriorly concave if it continues down onto the diaphragm or extends backwards into the horizontal fissure If it extends into the horizontal fissure it will have to be distinguished from a lesion of the middle lobe The normal position of the main fissure which will probably be thickened and therefore partly visible and the normal pattern of the middle lobe vessels and bronchi shown if necessary in tomograms, will serve to differentiate the two conditions Differentiation from a retrosternal mediastinal tumour may be difficult The diaphragm tends to be independent of such a tumour whereas it is often drawn up towards and therefore merges into the shadow of an effusion

Posteriorly encysted pleural effusion

The large homogeneous shadow produced by a posteriorly encysted pleural effusion may be confusing if seen only in the anterior (or posterior) view (Fig 31) Its nature will however be apparent from a lateral view in which it will be seen to lie well posteriorly extending backwards as far as the ribs. It will extend anteriorly for a variable distance depending on the size of the effusion and end with a moderately well defined anterior convex margin (Fig 32) Unless it is exceptionally large most of the shadow will lie behind the predicted line of the interlobar fissure which may be visible so that its anatomical extent and anterior convex margin will differentiate it from a consolidation of the apex of the lower lobe or posterior basal segment

If it is very large its situation would correspond closely to that of a large lower lobe abscess in such a case the patient would be too ill for elaborate radiological investigations such as bronchography or tomography which would differentiate these two conditions by showing bronchi in the opaque area in a consolidation with abscess An effusion however is much the commoner cause of such a shadow and should therefore be considered first A well-exposed posterior and a lateral view can always be obtained and these radiographs will serve as a guide in selecting the most favourable site for puncture if a diagnostic aspiration is indicated

A fluid level the presence of which may lead to a mistaken diagnosis of a lung abscess is often seen in an encysted effusion particularly when it is fairly acute and lies posteriorly It may be the result of a previous diagnostic aspiration with the unintentional introduction of some air or of a broncho-pleural fistula or even of a gas forming organism

When surgical drainage of the effusion is contemplated it is useful to mark its lower limit in relation to a rib This is easily achieved by introducing 5 millilitres of iodized oil into the pleural space at the time of the diagnostic aspiration Well-exposed posterior view and lateral view radiographs are then taken with the patient sitting up (Figs 33 and 34) and the lower limit of the opaque oil observed in relation to the posterior part of the particular rib



Fig 31 —Posteriorly encysted fluid (anterior view) The air producing the fluid level is from a diagno tic aspiration Mal aged 59 years Post pneumonic streptococcal empyema Cough sputum high f ver and leucocytosis



Fig 32 —Same case (lateral iew) Arrow marks the anterior limit of the empyema cavity The distance between the fluid l vel and the arrow ind cates the thickness of its wall



Fig 33 —Same case Arrow marks the l wer l mit of iodized oil introduced at the time of a d gn tic a pirat on in order to l cal ze the le el of the bottom of the ca ity in relat on to the ribs



Fig 34—Same case as F g 31 (lateral view patient s tt ng) Arrow marks an interlobar exten ion of the fluid Su gical drainage and rapid recovery

Pleural sinograms

Following surgical drainage of an empyema or lung abscess a *sinogram may be needed to outline* the sinus track and to show the size of the residual cavity which it is draining and the relation between the cavity and the sinus and drainage tube The technique used varies according to the purpose of the investigation in each case

The size of the residual space or cavity is best *shown if the* contrast medium is introduced while the patient is lying and the radiographs taken with the patient still in this position The contrast medium will then outline the whole of the cavity to which it has access, although it may not show the draining sinus

The relation of the cavity to the sinus track and drainage tube is most readily ascertained from sinograms taken with the patient in an upright position The contrast medium (usually iodized oil) is injected down the drainage tube actually in use and *in situ* Since this rubber drainage tube is often of relatively wide bore it is necessary to have an intermediate conical connecting piece which will fit any size of drainage tube likely to be used this is fitted between the tube and the syringe The space between the tube and the sinus wall should not be tightly packed with wool for fear of an oil embolus but if the patient lies with the opening of the sinus uppermost the contrast medium runs in almost by gravity *The syringe is withdrawn and the tube temporarily blocked* with a wooden spigot At this stage the tube may be lightly packed round with wool to stop the medium from running out between it and the sinus wall The patient then sits up while anterior (or posterior) and the appropriate lateral view radiographs are taken These will show whether the sinus track starts at the bottom of the cavity which will help dependent drainage or whether it emerges a short way up so that there is a dependent pocket below the exit The radiographs will also show whether the tube is of the correct length to encourage natural closure of the space or whether it is too far in so that the drainage is not complete or not in far enough so that there is danger of premature narrowing of the sinus track

Should a bronchopleural fistula be suspected an absorbable medium such as oily propyliodone (Dionosil) may be indicated The site of the fistula and the state of the nearby bronchi will generally be shown on the sinogram

Apical pleural opacity

An apical pleural opacity due to a cap of thickened pleura or an effusion over the apex is not uncommon and is generally secondary to an underlying parenchymal tuberculous lesion The shadow is homogeneous and usually has a well defined inferior concave margin If the trachea is deviated towards the shadow as is usually the case it must be differentiated from an atelectasis (with bronchostenosis) of an upper lobe particularly on the right side but none of the other changes seen in atelectasis will be present such as alteration in the vascular pattern fissure displacement compensatory emphysema or bronchial occlusion on tomography If the trachea is not deviated and there are no clinical clues such an apical opacity seen for the first time in an elderly male may be indistinguishable from a neoplasm in this region A neoplasm will be suspected if rib erosion can be *seen on the plain radiographs or demonstrated by tomography* and tuberculosis if underlying parenchymal small circular shadows can be seen Serial x ray observation will eventually give the correct diagnosis but whether such a waiting period is justified without exploration must be decided in each case on clinical grounds

Mediastinal pleural effusion

An encysted effusion of the mediastinal pleura is uncommon It will result in a homogeneous shadow with a very well defined lateral convex border projecting into the translucent lung field (Figs 35 and 36) Medially it will merge with the heart shadow and will not be separately demarcated from it It will therefore be similar to an encysted pericardial effusion or even a tumour of the heart In a lateral view it will often lie retrosternally and will thus be indistinguishable on the radiographs from a *mediastinal space effusion* a mediastinal tumour or an aneurysm of the ascending aorta Generally there will be some indication of the cause such as a pulmonary shadow suggesting it is secondary to a lung lesion or occlusion of a costo phrenic recess to indicate pleural thickening or effusion in other sites on that side



Fig. 35.—Mediastinal pleural effusion on the right side. Female aged 6 years. Recent onset of cough, sputum and tiredness. Fever 103 F. Miliary shadows in the lung. Some fluid obtained on aspiration; tubercle bacilli in sputum and on culture of fluid.



Fig. 36.—Same case (lateral view). The shadow of the fluid is superimposed on the heart shadow. It reaches the sternum in front. Arrow marks the posterior margin. Diaphragm normal and posterior recess clear. Resolution after streptomycin and PAS. Well 2 years later.



Fig. 37.—Abandoned extrapleural pneumothorax on the right side with the air replaced by fluid. Regenerating posterior part of the fourth rib. Abandoned intrapleural pneumothorax on the left side with air replaced by fluid. Elevation of the left dome from a phrenic interrupt.

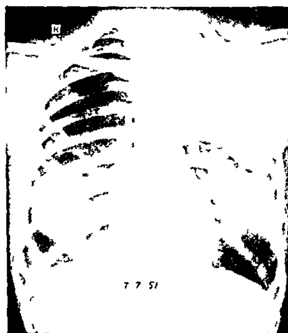


Fig. 38.—Plombage on left side with solid lucite balls. Some pressure atrophy of posterior parts of second and third ribs. Operation done for left upper lobe tuberculous cavity. Cavity closure achieved; sputum previously positive became negative. No recurrence 4 years later. Right artificial pneumo

Abandoned pneumothorax space

An old abandoned artificial pneumothorax space may fill up with fluid as the air absorbs and result in an encysted pleural effusion (Fig 37) The x ray appearances are the same as those just described but certain sites are more common for an abandoned pneumothorax than for an acute pleurisy with effusion The apex for example is a common site the homogeneous shadow being well demarcated below with an inferior concave curve Frequently there is deviation of the trachea towards the shadow This is usually caused by the inability of the re expanding lung to come out fully as a result of the healing of lesions with shrinkage of tissue and other factors of which adhesions to the thickened pleura may be one Proof of this is found when removal of the thickened pleura by a decortication operation is followed by full expansion of the lung and a return of the trachea to its normal central position This may also occur following disappearance of the pleural shadow which is more likely to be due to absorption of fluid than resolution and disappearance of fibrous tissue

A somewhat similar shadow is seen in the apical region following an extrapleural pneumothorax if the air is eventually replaced by fluid (Fig 37) Partial resection of one of the ribs is often necessary during the initial stages of the operation and the gap in the rib or the deformity of the rib as it regenerates as well as the clinical history will indicate that the shadow is probably due to extrapleural and not intrapleural fluid If the replacement of the air is with oil as in an oleothorax the shadow will be of a similar radio opacity but if there is some exudate as well the oil may float above this and the radio opacity be sufficiently different to give a horizontal level demarcating the rather more opaque exudate from the lighter oil

Another common site for the intrapleural fluid following a pneumothorax is down the axilla (Fig 37) The homogeneous shadow may be a continuation of an apical effusion or may start just below the clavicle and continue down the axilla sometimes reaching to the diaphragm It may be quite a narrow band or several centimetres wide and it generally has a well defined medial margin which is rather straighter than that seen with an acute axillary encysted effusion

A third position is in the lower half of the chest where the fluid is encysted in a thin layer posteriorly and gives a homogeneous haze over the lower zone with a poorly defined upper margin It may be difficult to identify such a thin layer of fluid in the plain lateral view but lateral view tomograms will show it clearly and thus confirm the nature of the haze

Apical plombage

Another homogeneous shadow over the apex and upper part of a lung field is seen following an extrapleural plombage with solid lucite balls (Fig 38) The surrounding exudate and fibrous tissue are of much the same radio opacity as the balls so that the latter cannot be separately identified The history will usually indicate the nature of the homogeneous shadow the lower margin of which either slopes downwards and outwards or lies more or less horizontal with a slight inferior convex curve

LOBAR CONSOLIDATION

(LARGE HOMOGENEOUS SHADOW WITHOUT GROSS SHRINKAGE)

A large homogeneous shadow occupying the normal position of a lobe but without evidence of appreciable fissure displacement and therefore of gross shrinkage may be caused by a massive consolidation of the whole or a large part of a lobe This in turn may be due to a great variety of lesions in any of which the alveolar air in a lobe is replaced by fluid or cells for example bacterial or viral pneumonia pulmonary oedema from circulatory failure noxious gases or biochemical disasters invasion by neoplastic cells in some forms of carcinoma lymphadenoma or other reticuloses a locally invasive neoplasm such as alveolar cell carcinoma (pulmonary adenomatosis) or injury after x ray or radium therapy

The x ray appearances are the same whatever the cause of the consolidation In most cases the cause is obvious on clinical diagnosis but in a few cases there are no clues to the diagnosis in the initial stages of the investigations Sometimes even a bacterial consolidation may cause singularly little disturbance to the patient whilst a lobar consolidation from some forms of neoplasm may be virtually asymptomatic



Fig 39 —Consolidation of the anterior and posterior segments of the right upper lobe and nearby parts of the apical segment Bacterial pneumonia The horizontal fissure forming th lower border of the shadow shows a slight inf rior concave curvature thus ind cating some shrinkage of the lobe



Fig 40 —Same case (lateral view) Shadow sharply demarcated at interlobar fissures and poorly d marcated where it borders on the api al segment In this vi w the slight elevation of the horizontal fi sure indicates some shrinkage of the lobe There was no stenosis of the lobar bronchus and resolution was rapid



Fig 41 —Consclidati n of the left lower lobe B terial pneumc nia Arrow pcints to the gas cap of the stomach



F g 4 —Same case (lateral view) Arrow points to gas cap the upper part of which indicates the le el of the left d me

Frequently only a part of the lobe is consolidated a common finding with the present form of disease and present methods of treatment The presence of a poorly demarcated edge to the shadow (usually the upper border) where it is adjacent to a small area of still aerated lung is an important feature in the x ray diagnosis (Fig 39) The exact site or extent of the still aerated portion or the margin of the shadow bordering on this will be the same whatever the cause of the consolidation and will therefore give no clues to the diagnosis An alveolar carcinoma (pulmonary adenomatosis) may occupy the same area as a bacterial pneumonia and have the same ill defined margin where it borders on still aerated lung whilst a bacterial pneumonia may be circular and simulate a neoplasm for a short time (Fig 55)

Distinction between a neoplasm invading or pushing the lung tissue aside from one infiltrating the intra alveolar spaces can only be made on histological examination

Distinction between consolidation with or without lung shrinkage and an unusual effusion can often be made from tomograms if there is any doubt concerning the nature of the shadow In consolidation without bronchostenosis these will show the larger air containing bronchi lying within the opaque area (Fig 62) a feature which will not be seen if the opacity is pleural In consolidation with bronchial occlusion the bronchostenosis will be seen in the tomograms and these will serve further to differentiate the shadow from that of a pleural effusion by demonstrating the alteration of vessel pattern and fissure displacement which are so characteristic of those conditions associated with lobar shrinkage

Resolution of a consolidation of a lobe is often somewhat uneven and some areas re aerate more rapidly than others with the result that the shadow at this stage is no longer homogeneous

When the whole lobe is consolidated the resulting shadow corresponds in size shape and position with the expected configuration of the lobe (Fig 42) The interlobar fissure which corresponds with the well demarcated adjacent border of the consolidated lobe is either not displaced at all or is only slightly displaced in the direction of the shadow In the latter case the slight shrinkage of the lobe is due to collapse of some alveolar groups This slight shrinkage of the lobe is in marked contrast to the shadows seen resulting from lobar bronchial obstruction when the decrease in size is commonly greater and is clearly shown by the considerable displacement of the interlobar fissure (Compare Fig 44 showing consolidation of the middle lobe with Fig 75 showing atelectasis of the middle lobe from bronchostenosis)

The trachea is either not displaced at all or is displaced slightly towards the shadow The heart is not displaced but the diaphragm may be raised and show some restriction of movement

Comparison with lobar atelectasis

The examples of consolidation with very little or no collapse which are shown in Figs 39–44 should be compared with the shadows seen when there is gross lobar shrinkage or atelectasis often distal to stenosis of a lobar bronchus and which are illustrated in Figs 63–90

It must be admitted that the radiographic picture is not always as clear cut as in many of these illustrations For instance a bronchial occlusion from a carcinoma may show comparatively little lobar shrinkage if the neoplasm occupies most of the lobe or if the distal inflammatory changes are severe and the bronchi much dilated and filled with mucus or pus (Fig 72)

More rarely a chronic pneumonia may proceed to gross lobar shrinkage or collapse without there being any stenosis of the lobar bronchus and without obvious cavitation or fibrosis so that the shadow remains homogeneous Such a case is shown in Fig 61 At first the appearances were similar to Fig 47 and indicated consolidation with the antero superior border passing downwards and forwards in a well defined straight line In the course of a few weeks the shadow became smaller the fissure moving posteriorly and showing a well marked anterior concave curve In fact the appearances were identical with those seen with collapse of a left lower lobe distal to a lower lobe bronchostenosis

The mechanism of this shrinkage or atelectasis is uncertain In this particular case bronchoscopy was normal and the larger bronchial air translucencies were normal on tomography as well as on examination of the resected lobe There may have been occlusion of a sufficient number of the smaller bronchi to block the access of air and thus cause the collapse During the early stages of resolution of an acute pneumonia a similar but more limited lobar shrinkage with fissure displacement towards the opaque area is often seen lasting for a few days

Right upper lobe consolidation

Consolidation of the whole of the right upper lobe is not very common in adults but is seen more frequently in young patients The shadow extends from the apex downwards to end in the anterior view radiograph with a well defined inferior margin running horizontally to meet the sixth rib in the axilla and thus corresponding to the normal position of the horizontal fissure In the lateral view the shadow has a well defined posterior margin running downwards and forwards along the normal line of the main fissure as far as the level of the lower end of the tracheal translucency from which point it has a well defined inferior margin running directly forwards in a line corresponding to the normal position of the horizontal fissure (*See* Figs 39 and 40 which apart from the translucent apical segment show similar x ray appearances to those of right upper lobe consolidation)

Left upper lobe consolidation

Consolidation of the whole of the left upper lobe is seen in the lateral view as a homogeneous shadow with a well defined postero inferior margin corresponding to the normal position of the main fissure It extends down from the posterior inferior edge of the body of the fourth thoracic vertebra to meet the diaphragm 1–1¼ inches behind the sternum Sometimes the lingula is not affected in which case the shadow has a poorly demarcated lower margin at a level corresponding to the lower end of the tracheal translucency

Right middle lobe consolidation

Consolidation of the right middle lobe is illustrated in Figs 43 and 44 In the anterior view the upper border of the shadow is sharply defined as it runs horizontally to meet the sixth rib in the axilla The shadow occupies the rest of the lung field below this although if there is some aerated lung in the region of the medial segment it may be less opaque near the right heart border In the lateral view it has a



Fig 43 —Consolidation of the right middle lobe Female aged 6 years Low grade bacterial pneumonia resolved in 3 weeks The shadow is sharply demarcated above by the horizontal fissure Slight elevation of the right dome Heart may be slightly to the right but the position of the sternal ends of the clavicles in relation to the vertebra indicates some rotation of the patient to the right.



Fig 44 —Same case (lateral view) Arrow marks position of left dome The shadow of the right dome is seen just above it The shadow of the consolidated lobe is sharply demarcated by the interlobar fissures The horizontal fissure forming the upper margin slopes downwards, indicating slight shrinkage of the lobe The posterior margin formed by the main fissure is quite straight and lies in the normal position of the fissure

triangular shape with the apex near the lower end of the tracheal translucency From here the well defined upper border runs directly forwards to meet the sternum If there is slight lung shrinkage this border may be inclined slightly downwards The postero-inferior border is also sharply defined and runs downwards and forwards to meet the diaphragm 1½ inches behind the sternum The shadow is very different from that seen when there is marked shrinkage of the lobe Fig 75 for example illustrates the small size of the shadow the greater downward inclination of the superior border and the forward displacement of the posterior border which corresponds to the displaced main fissure and has a posterior concave curvature which are all indications of the lobar shrinkage secondary in this case to bronchostenosis and atelectasis

Lower lobe consolidation

Consolidation of the right lower lobe gives an appearance almost identical to that of the left lower lobe illustrated in Figs 41 and 42 In the anterior view the upper margin of the shadow is poorly defined and usually lies in the region of the second rib anteriorly though it may not extend quite as high as this if there is some shrinkage of the lobe or if the extreme apex of the apical segment of the lower lobe is still aerated In the lateral view the shadow is well demarcated antero-superiorly at the line of the interlobar fissure which lies either in its expected position or slightly posteriorly to this

Consolidation with effusion

If a small effusion develops while the lower lobe consolidation is still present the shadow may remain homogeneous and show little or no alteration in size shape or position In fact the shadow of the fluid cannot be separately identified unless some aerated lung is present between the two or unless the consolidation is beginning to resolve so that this part of the shadow is no longer homogeneous or unless the shadow of the effusion extends up the axilla as a line shadow beyond the main basal shadow

SEGMENTAL CONSOLIDATION

Consolidation of a segment or part of a segment results in a homogeneous roughly triangular or pyramidal shadow examples of which are illustrated in Figs 45–60 To call these triangular or pyramidal shadows segmental shadows is not however justified since there is as yet no confirmed correlation between their appearance on the radiograph and the morbid histology of the lesion which they represent The localization of the shadow to a particular segment can be determined with accuracy but not exactly how much of the segment is involved Even if the whole segment is consolidated the shadow is only clearly demarcated where it adjoins an interlobar fissure and is ill-defined where it *adjoins another segment because of the interdigitations at the so called segmental plane* In addition *the consolidation near this plane is frequently incomplete so that one margin of the shadow does not* extend as far as the predicted segmental boundary An example of this is shown in Fig 58 where the shadow covers only the lower part of the posterior segment of the right upper lobe

When the consolidation is confined to a sub-segment only it is even more difficult to determine how much of the sub-segmental area is involved The presence of a small triangular shadow with its apex pointing towards the hilum is suggestive of a sub-segmental consolidation and is particularly common in the basal region in cases of so called aspiration pneumonia and in virus pneumonia Where bronchograms have been done at a later date the distribution of the slightly abnormal bronchi suggest that the lesion did not involve a complete segment In more chronic cases due to tuberculosis the examination of the specimen after resection shows neither the exact anatomical boundaries nor whether these are strictly confined to one segment or a sub-segment

These triangular shadows representing a segmental or partial segmental consolidation are not infrequently found during a routine x ray examination for some other purpose such as an annual radiograph of nurses or students and they generally resolve within a fortnight The shadows are commonly seen in the winter months especially if there is an epidemic of upper respiratory tract infection They are also seen in some cases of asthmatic bronchitis with or without eosinophilia when they are commonly found in the upper lobes They are seen in many obscure cases of localized consolidation such as are sometimes found in association with rheumatoid arthritis and periarteritis nodosa

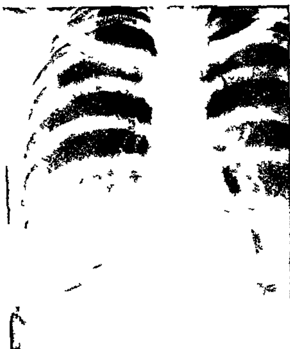


Fig 45—Consolidation of the medial segment of middle lobe (5) The costo-phrenic region is clear and the diaphragm is slightly elevated Bacterial pneumonia



Fig 46—Same case (lateral view) Opacity in sterno-diaphragmatic angle The straight posterior margin corresponds to the expected position of the interlobar fissure



Fig 47—Consolidation of the lateral segment of the middle lobe (4) Bacterial pneumonia



Fig 48—Same case (lateral view) Arrow marks line of thickened interlobar fissure



Fig. 49.—Consolidation posterior segment right upper lobe (4). The line of the horizontal fissure visible 1 centimetre below the [illegible] pneumonia [illegible] three days cough, abdominal pain, anorexia and vomiting. High fever and rapid pulse.



Fig. 50.—Same case (lateral view). Arrow marks posterior margin of consolidated area. The anterior margin of the shadow is poorly demarcated where it borders on the apical segment. Rapid resolution. Radiographs of lung a fortnight later were normal.



Fig. 51.—Consolidation posterior basal segment right lower lobe (10). Bacterial pneumonia.



Fig. 52.—Same case (lateral view). Arrow marks left dome. Right dome visible above it.

Upper lobe segmental consolidation

Consolidation of the apical segment of the right upper lobe is not very common The resulting triangular shadow occupies roughly the same area as the translucent zone which in Figs 39 and 40 lies between the areas of opacity representing the consolidated anterior and posterior segments In this particular example the consolidation has spread beyond the segmental boundaries so that in fact the shadow of a consolidated apical segment would be rather larger than the translucent zone and in the lateral view particularly would extend down to the level of the interlobar fissure

Consolidation of the anterior segment alone is much more common In the anterior view the shadow is sharply demarcated below by the horizontal fissure and therefore has a sharply defined margin running straight across the lung field to meet the sixth rib in the axilla If there is some shrinkage of the consolidated segment this margin is slightly concave downwards The upper margin is rather poorly defined and beyond it the apex and the region medially just below the clavicle remain translucent In the lateral view the shadow extends from the middle of the chest to the sternum and its well defined lower margin is clearly seen

Consolidation of the posterior segment of the upper lobe gives a very similar shadow to the anterior segment in the anterior view (Fig 49) The lower margin is often equally well defined but it does not reach quite as low as the horizontal fissure which is seen as a faint linear shadow 2–3 millimetres below it In a lateral view the shadow lies posteriorly and has a well defined margin where it is demarcated by the upper end of the main interlobar fissure (Fig 50)

Consolidation of the posterior segment on the left side is usually associated with consolidation of the apical segment and their combined shadow occupies the medial half of the upper zone The lateral margin of this shadow is usually poorly defined

The anterior segment of the left upper lobe on the other hand is occasionally the only segment to be consolidated The shadow is then similar to that of the anterior segment of the right upper lobe already described except that the lower margin borders on the lingula instead of on the horizontal fissure and is therefore less well defined

Lingular consolidation

Consolidation of the lingula is probably present more often than is realized since the shadow may be very inconspicuous or obscured by a large breast shadow in the anterior view or by the heart shadow in the lateral view In the anterior view there may be no more than a faint haze adjacent to the apex of the heart, but sometimes a more definite area of opacity can be seen as in Fig 59 The lower part of the lung above the costo phrenic recess remains clear

In the lateral view the shadow is superimposed on that of the heart It is sharply demarcated posteriorly by the line of the interlobar fissure which is not displaced and runs in a straight line downwards and forwards (Fig 60) This straight posterior margin is characteristic and should be compared with that shown in Fig 90 which owing to bronchostenosis and shrinkage of the lobe is posteriorly concave Anteriorly the shadow of a lingular consolidation reaches to the sterno diaphragmatic angle but is poorly demarcated antero superiorly where it adjoins the anterior segment The shadow is often difficult to see in a plain left lateral view but can be clearly seen in left lateral tomograms

Consolidation of the postero inferior part of the lingula adjacent to the main fissure may be associated with consolidation of the posterior segment of the upper lobe In the anterior view a triangular shadow is seen with its base in the mid axilla and its apex at the hilum (Fig 57) In the lateral view (Fig 58) the shadow of both segments are sharply demarcated postero inferiorly by the line of the interlobar fissure Anteriorly both are poorly defined as they approach the apical segment of the upper lobe and the superior part of the lingula respectively mainly because the consolidation of the segments is usually incomplete

Middle lobe segmental consolidation

Consolidation of the medial segment of the middle lobe may give no more than a faint area of clouding adjacent to the right heart border in the anterior view (Fig 45) Such a shadow is easily *mistaken for a breast or muscle shadow or may even be overlooked* In the lateral view however it stands out quite clearly (Fig 46) Posteriorly it is sharply demarcated by the lower end of the main



Fi 3 Consolidation of the apical segment of the left lower lobe (6) Shadow poorly demarcated Male aged 9 years Bact rial pneumonia Rapid resolution Lungs lear a f rtnight later



Fig 54 —Same case (lateral view) Arrow points to anterio margin of shadow whi h is well demarcated by the interlobar fissure anteriorly but poorly demarcated inferiorly where it is adjacent to the posterior basal segment



Fig 55 —C nsol dati n of the apical segment of right lower l be (6) C rcular ha low mistaken f r a n oplasm Also consolidated anteriorl and part f lateral basal segment Bacterial pn umonia with rap d resolution and disappearance of all had ws



Fi 56 —Same case (lateral view) The black arrow po nts t the ap cal segment of the right lower lobe The white arrow po nts to the interlobar septum with the shadow of the consolidated anter r and lateral basal segments just bel w



Fig 57 —Consolidation of the posterior segment of the left upper lobe and part of lingula Male aged 40 years Sudden onset of left chest pain malaise cough with rusty sputum and leucocytosis Rapid resolution



Fig 58 —Same case (lateral view) Arrow marks posterior border of heart Both segments are sharply demarcated posteriorly by the interlobar fissure which is not displaced but poorly demarcated anteriorly because this part of the segment is still aerated



Fig 59 —Consolidation of the lingula Tuberculous pneumonia Female aged 7 years. Resolution on medical treatment



Fig 60 —Same case (lateral view) White arrow marks main fissure Black one marks right dome left dome just above it

fissure which is not displaced Inferiorly it occupies the sterno diaphragmatic angle above it is less clearly demarcated and does not extend as far towards the hilum nor along the posterior half of the horizontal fissure as in the case of consolidation of the whole of the middle lobe (compare with Fig 44) If the breasts are large or the patient obese so that the shadow is indistinct confirmation of these characteristic appearances is readily obtained from a right lateral view tomograph

A consolidated lateral segment of the middle lobe gives a more conspicuous shadow than the medial segment in the anterior view, usually being more clearly demarcated above by the line of the horizontal fissure (the case illustrated in Fig 47 is a rather unusually ill defined example because the base of the posterior segment is also consolidated) The shadow extends down the axilla almost to the costo-phrenic recess An area of normal lung is seen infero medially in and above the cardio diaphragmatic angle In the lateral view (Fig 48) the shadow is much less conspicuous, but can just be seen either partly superimposed on or lying just below the hilar vascular shadow It occupies a rather broad triangular zone clearly demarcated above by the posterior third or half of the horizontal fissure and behind by the main fissure Antero inferiorly it is less well defined owing to the inter segmental digitations into the medial segment. The sterno diaphragmatic area occupied by the normal medial segment remains clear Again the shadow and fissure lines can be more clearly demonstrated in right lateral tomograms than in the plain radiographs

Lower lobe segmental consolidation

Consolidation of the apical segment of the lower lobe on either side is usually incomplete but when most of the segment is consolidated a characteristic homogeneous shadow is seen In the anterior view it is ill defined and spreads out from the region of the hilum into the mid zone It may reach as far *as the axilla (Fig 53) In the lateral view the shadow is roughly circular and tends to be partly obscured* by the superimposed vertebral scapular and lower axillary muscle shadows Antero superiorly it is demarcated by the upper third of the main fissure but the line of this is generally indistinct in the plain lateral view Antero inferiorly it curves downwards and backwards (Fig 54) and is poorly demarcated where it is adjacent to the posterior basal segment The shadow of the consolidated area and that of the upper end of the main fissure can be seen much more clearly in a lateral view tomogram than in a plain lateral view

Consolidation of any of the basal segments is quite common especially as a result of a so called aspiration pneumonia Usually only a part of one segment is consolidated giving a rather small triangular shadow with its apex towards the hilum and its base on the diaphragm Quite commonly a part of a neighbouring segment is also affected neither segment being totally consolidated

Consolidation of the anterior basal segment is more commonly seen on the right than on the left side The shadow lies rather medially in the anterior view In the lateral view (Fig 56) it is well *demarcated anteriorly where it borders on the lower end of the main fissure (In Figs 55 and 56 the* lateral basal segment is also partly consolidated)

In consolidation of the lateral basal segment the shadow lies in the outer half of the lung field in the anterior view occupying the costo phrenic recess *In the lateral view it is triangular in shape* and lies in the middle of the lung (rather more posteriorly than the shadow of the anterior basal segment seen in Fig 56) and barely reaches the interlobar fissure

Consolidation of the posterior basal segment is common on either side particularly in children In the anterior view the roughly triangular shadow extends from the hilum almost to the costo phrenic recess (Fig 51) It is often not very clearly demarcated laterally but reaches the diaphragm in the medial half In the lateral view (Fig 52) it is poorly demarcated where it borders on the apical segment of the lower lobe above and the other basal segments anteriorly It extends down to occupy the posterior costo phrenic recess

Lobar Atelectasis (or Collapse) from Stenosis of the Lobar Bronchus or from Unknown Cause

Stenosis with effective occlusion of a lobar bronchus results in atelectasis (or collapse) of that lobe and the radiograph then shows a homogeneous shadow with evidence of lobar shrinkage Pathologically there are almost invariably other changes present apart from just airlessness of the lobe and

consequent apposition of the alveolar and bronchiolar walls At the very least there is an outpouring of fluid exudate into the alveoli and usually there are varying degrees of cellular exudate in fact pneumonic consolidation with lung shrinkage In addition there are varying degrees of bronchial dilatation with erosion or thickening of the walls of the larger bronchi and occlusion of some of the smaller ones In a long standing collapse the histological findings may include irregularity of the bronchi with papillary folding of the epithelium an increase in the thickness of the interlobular septa and a decrease in the number of the alveoli There is also capillary dilatation although it is known that there is a decreased flow of blood through the collapsed lobe

Lobar atelectasis (or collapse) may also be present without any present evidence of stenosis of the lobar bronchus It may be the result of a previous transient occlusion such as may result from the pressure from enlarged tuberculous glands These may subside so that the stenosis is relieved but the lobe may remain small and shrunken if irreversible changes have occurred which are most often the result of a superadded infection Lobar atelectasis may also be the end result of a chronic pneumonia without there having been stenosis of the lobar bronchus at any time In such a case there is possibly occlusion of a number or all of the smaller bronchi with resulting airlessness



Fig 61 —Consolidation of the left lower lobe with gross shrinkage Male aged 48 years Sudden onset left chest pain and fever Physical signs dullness diminished breath sounds At first shadow corresponded to lower lobe and it then started to shrink backwards Bronchoscopy showed pus in lower lobe but no stenosis



Fig 62 —Same case (later view tomogram) An arrow marks air-containing bronchi in opaque lobe Cavities are seen in the apical segment Two months later resected No stenosis of larger bronchi Much dense fibrosis and non specific inflammatory changes Cavities in apical segment No evidence of tuberculosis or neoplasm

In those cases in which there is no longer stenosis of the lobar bronchus the larger bronchi are filled with air and are usually dilated so that they give tubular translucencies within the area of opacity in a well exposed film or in tomograms On the other hand if there is bronchial occlusion the opacity of the shrunken lobe is quite homogeneous in spite of the bronchiectasis since no air can gain access to the dilated bronchi which fill up with retained secretions or pus

The size of the airless shrunken lobe depends to some extent on the duration of the obstruction on the severity of the distal bronchiectasis and chronic pneumonia and on the condition of the lung before the occlusion whether proximal or distal became effective The smallest airless lobes are seen when the stenosis is long standing and when the distal lung changes are either slight or of late onset coming

on after the lung had collapsed—conditions which are most commonly fulfilled in tuberculous endobronchitis and bronchial adenoma. The largest airless lobes are seen associated with a bronchial carcinoma when much inflammation and retained secretion had already occurred distal to the stenosis before the effective occlusion developed or when the neoplasm already occupied much of the lobe. In fact the lobar shrinkage may be so slight in such a case that the appearances on the plain radiograph simulate those of consolidation without shrinkage and without bronchostenosis (Fig. 72).

The shape and position of the shadow depend on which lobe is collapsed, the degree of shrinkage and the presence or absence of pleural adhesions. The shrinkage is made obvious by the displaced position of the interlobar fissure which corresponds to the border of the shadow where it is adjacent to aerated lung. A part of the fissure remote from the collapsed lobe may also be displaced, an example of this being the downward displacement of the horizontal fissure frequently seen with collapse of the right lower lobe.

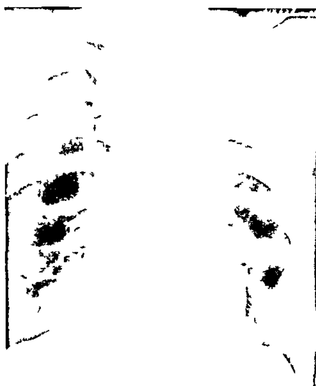


Fig. 63.—Atelectasis of the left upper lobe. Trachea to left. Hilar vessel shows a lateral convex outline with small vessels radiating off the main stem at abnormal angle. Fewer vessels per square centimetre than on right. Hazy upper half, slight hypertranslucency of lower half. Slight relative elevation of left diaphragm.



Fig. 64.—Same case (lateral view). Arrow points to the posterior border of tongue-like shadow. Translucent area between the front of this and the sternum. No connexion of the shadow to hilum can be seen. Male aged 65 years. At resection small carcinoma occluding upper lobe bronchus, shrunken airless upper lobe, lingula adherent below.

The radiograph will often show slight elevation of the diaphragm on the affected side, especially if a middle or lower lobe is involved. The heart and trachea may be slightly deviated to the affected side but this is often not a very conspicuous feature or else cannot be demonstrated with certainty owing to the asymmetrical position of the patient or to slight scoliosis. Displacement of the trachea is most commonly seen and most marked if an upper lobe is affected and displacement of the heart if a lower lobe is atelectatic.

The appearance of the neighbouring lobe is altered since it has to occupy more space than it normally would. It will therefore show the x-ray changes of compensatory emphysema (*see* p. 101) and will be slightly hypertranslucent relative to the other side, the vessels will be more widely spaced than normal and the main hilar vessel pattern will be altered. This alteration of the vascular pattern is sometimes seen most clearly in tomograms and may be an important diagnostic feature. The tomograms will

also show the encroachment of the shadow on the lobar bronchial air translucency at the site of the stenosis

Left upper lobe atelectasis

Left upper lobe bronchostenosis with atelectasis almost inevitably includes the lingula In the anterior view the characteristic appearance is a rather faint homogeneous opacity in the upper half of the left lung with a poorly demarcated lower margin (Fig 63) It may not quite reach to the axilla or the apex if the lobe shrinks towards the hilum leaving the apex free to be occupied by the over inflated lower lobe Vascular markings can be seen superimposed on the shadow but these are spread out so that there are fewer per unit area than in a corresponding area on the right side They are of course lower lobe vessels lying behind the collapsed lobe The hilum shadow is abnormal and is oval in shape with vessels of smaller calibre than normal coming off at unusual angles Tomograms will show this alteration of the vascular pattern very clearly and may show the stenosis of the bronchus as well



Fig 63—Atelectasis of the left upper lobe Arrow marks lateral convex border of the lobe which has retracted medially and anteriorly Remainder of lung more translucent and shows fewer vessels than on the right Left dome same level as right indicating some relative elevation



Fig 64—Same case (lateral view) Arrow marks anterior border of lobe lying retrosternally The shadow extends backward to the hilum where the calcified gland causing the stenosis casts a dense shadow Female aged 19 years Tuberculous stenosis of the left upper lobe bronchus

In the left lateral view quite characteristic appearances are seen (Fig 64) There is a tongue like shadow lying anteriorly the posterior margin of which lies well in front of the expected line of the interlobar fissure (that is in front of a line drawn from the lower posterior edge of the fourth thoracic vertebra to meet the diaphragm 1½ inches behind the sternum) A faint 2–3 centimetre posterior extension of the shadow can usually be identified joining it to the hilum Anteriorly the shadow either reaches to the sternum or lies slightly posterior to it with a well-defined margin running downwards a short distance behind the lower third the space between being then occupied by a part of the lower lobe The apex of the tongue reaches to the diaphragm

Small variations of these appearances are sometimes seen The tongue may be very thin and narrow with its apex well above the level of the diaphragm if the lobe is very small and retracted upwards

or it may be quite wide reaching the diaphragm and only distinguishable from a consolidation without shrinkage by the posterior concave indentation of its posterior margin Occasionally especially in children the lingula may escape or the lobe shrink in an upward and forward direction ending up as a 2–3 centimetre oval shadow in the retrosternal region (Fig 66) thus simulating a mediastinal tumour Careful inspection of the vascular pattern in the anterior view (Fig 65) will reveal the changes described above and will thus indicate the correct diagnosis

Right upper lobe atelectasis

In a typical case of right upper lobe bronchostenosis with atelectasis the homogeneous opacity of the shrunken lobe is seen in the anterior view radiograph extending from the hilum upwards and slightly outwards with a well defined lateral margin The shadow then continues laterally across the apex where the lower margin has a well defined inferior concave curve (Fig 67)

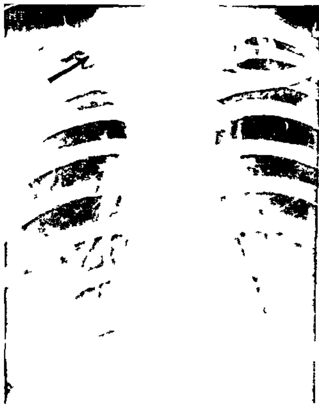


Fig 67 —Atelectasis of the right upper lobe Arrow marks lower border of shrunken lobe Fewer vessels in the lung below than on the left side and the difference between the right and left hilar shadows is shown Tubercle bacilli in sputum Treated by resection There was stenosis of the upper lobe bronchus from healing tuberculous endobronchitis

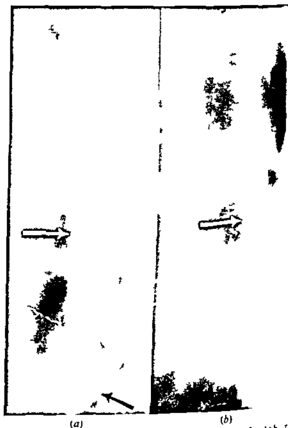


Fig 68 —(*a*) Same case (posterior view tomogram of right hilar vessels) The slight lateral convexity of the main vessel group is shown opposite the arrow Compare with tomogram of a normal person (*b*) in which there is a lateral concavity (opposite arrow) between the upper lobe group of vessels above and the lower group passing downward Back arrow (*a*) points to a pulmonary vein

Three variations of this shadow are seen If there is much consolidation distal to the stenosis the shadow will be relatively larger and the inferior margin may run almost straight across to meet the third rib in the axilla (Fig 72) Alternatively if the stenosis is long standing and the *distal changes* slight the lobe may shrink to a very small size so that the lower half lying medially just above the hilum will be very inconspicuous on the radiograph and will simulate a widening of the mediastinal shadow The upper half of the collapsed lobe will still be seen passing across the apex *with an inferior concave* margin well above the clavicle A third more rare variation is seen in a long standing stenosis with slight distal changes if the lobe shrinks medially and downwards The shadow will then lie just above and in front of the hilum (Fig 69) and in a lateral view will reach to the sternum thus simulating a mediastinal tumour (Fig 70)

With all four types of shadows certain other features will usually be present which will assist the diagnosis The right dome of the diaphragm may be slightly raised and show some restriction of movement This is however rarely a conspicuous feature and in many cases may not be present The trachea is displaced a short distance to the right but to a lesser degree than is often the case with pleural thickening over the apex The latter lesion may give rise to a very similar shadow but there will be no hypertranslucency and no abnormalities of the vascular pattern Below the shadow of the collapsed right upper lobe there is slight but definite hypertranslucency of the lung This is also not a conspicuous feature and will not be detected if the left side is abnormal and therefore not suitable for comparison



Fig 69—Atelectasis right upper lobe with shadow simulating a tumour The well defined lateral convex border of the shadow is seen superimposed on and above the hilum Slight hypertranslucency of right lung with very many fewer vessels visible than on the left side Trachea central Male aged 4[illegible] years no symptoms



Fig 70—Same case (lateral view tomogram) Arrow marks lower limit of shadow which extend forwards to the sternum Dense calcification towards hilum This was a tuberculous gland which was causing stenosis of the upper lobe bronchus The lobe was airless with some dilated mucus filled bronchi and some fibrosis

The most important and constant change is the alteration in the vascular pattern The density of the vessels (that is the number per unit area) below the shadow of the collapsed lobe is less than in a corresponding area on the left side The hilar vessels appear to be too narrow since the first branches seen are in reality only segmental branches whereas in a normal lung the first branches seen are the larger lobar branches In addition the characteristic lateral concavity (the Y shaped pattern) of the main hilar vessels is lost (Fig 68) Normally this is the result of the division of the right main artery almost as soon as it emerges from the central shadow into a branch directed upwards to supply the upper lobe and another branch directed downwards to supply the middle and lower lobes In a patient with atelectasis of the right upper lobe the central part of the hilar vascular shadow is convex laterally a feature which may be apparent in a plain radiograph (Fig 67) and will be particularly clearly seen in a posterior view tomogram taken at the level of the hilum This layer of the tomogram or the next one to it will also show an alteration in the main bronchial translucencies The absence of the upper lobe bronchial translucency in its normal position and its narrowing or occlusion in a more medial position will be demonstrated It will be seen to point upwards towards the opaque lobe instead of almost directly laterally

may shrink to a very small size giving a narrow 2–5 millimetre wide spindle shaped shadow (Fig 79). This is seen particularly as a result of stenosis from a tuberculous gland in the neighbourhood of th middle lobe bronchus The offending gland and its relation to the bronchus may be seen if the gland is partly calcified whilst the stenosis or occlusion may be demonstrated in tomograms For this purpo a posterior oblique view tomogram (45 degrees rotation of the patient) is better than a true right lateral view since the bronchus is then more nearly parallel to the film and tomographic layer In a doubtful case a bronchogram will show the occlusion of the middle lobe bronchus or if they fill, crowding shortening and dilatation of the bronchi in the shrunken lobe (Fig 79)

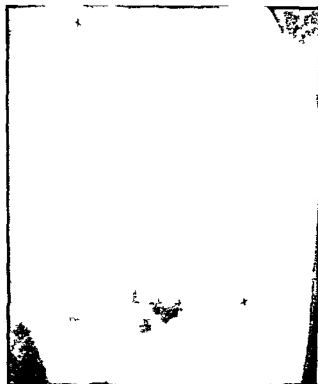


Fig —Atelectasis of the right middle lobe (lateral view) The upper border of the shadow formed by the horizontal fissure sloped ... nward and the posterior border formed by the main fissure which has displaced forward shows a posterior concave curve The two small crosses represent the points (1½ inches behind the sternum and the posterior inferior border of the fourth thoracic vertebra) between which a line can be drawn to indicate the expected position of the main fissure



Fig 6—Atelectasis of the right middle lobe (lateral view and a different case) A spindle shaped shadow is seen around a line in the expected position of the main fissure. At operation a small carcinoma was found obstructing the middle lobe bronchus The lobe was airless and small and the fissure was adherent to the diaphragm so that it could not easily swing forwards Male aged 46 years with haemoptyses

Lingular atelectasis

In lingular bronchostenosis with atelectasis the shrunken lobe casts such a very faint shadow at the left base adjacent to the heart shadow that it may be difficult to see it at all in a routine anterior view (Fig 89) In a left lateral view a well defined tongue like shadow may be seen in the lower half of the lung The anterior edge may either reach the sternum or may be 1–2 centimetres posterior to it while the posterior edge which includes the fissure has a well defined posterior concave border lying well forward of the expected line of the interlobar fissure (Fig 90) The shadow is in fact the same as that seen with atelectasis of the upper lobe only it does not extend so high up The condition is not very common and the shadow may be difficult to see even in the lateral view because of the superimposed heart shadow and in some women patients the breast shadows It will however stand out very clearly in left lateral tomograms which are therefore indicated if this condition is suspected, but not clearly demonstrated in the plain radiographs

The translucency of the lingular bronchus cannot be demonstrated with the same certainty in tomograms as that of the right middle lobe bronchus which is more easily positioned parallel to the



Fig. 77.—Atelectasis of the right middle lobe. The anterior view was almost normal and only a very indistinct line shadow can be seen in this plain lateral view.



Fig. 78.—Same case (right lateral tomogram). The line shadow marked by the arrow is now quite distinct. Small shrunken middle lobe confirmed at operation.



Fig. 79.—Atelectasis of the right middle lobe (lateral view bronchogram). The deformity of the middle lobe bronchus can be seen with slight bronchiectasis and much shortening and crowding of the bronchi. Arrow marks top of right dome.



Fig. 80.—Atelectasis of the right middle lobe (same case lateral view tomogram). The lobe has shrunk to a very small size and a calcified gland is seen adjacent to the narrowed bronchus. In the plain film both features were indistinct. Female aged 25 years. Cough and sputum 1 year.



Fi 81 —At lecta i of the medial segment of the middle lobe Arro point to the line of th horizontal fis ure which ha been tou h d up Clear area of lung between this and paque shrunken lobe belo Male a ed 49 years Pain in the right hest and lo of w ight



Fi 82 —Atelecta i of the anterior and posterior segments f ri ht upper lobe (lateral view tomogram) White arrow points to posterior segment black arrow to shrunken opaque anterior segment Confirmation at operation both bronchi narrowe l by tuber ulou tenosis



Fi 83 —Same ase a Fig 81 bron h gram Upper arrow mark the lateral bran h f apical lower lobe lower arrow the lateral bran h of m ddle lobe (4) N te absence of filling f medial d vi i n ( ) The paracardia divi ion some di tance bel w t the cardia bronchu



Fig 84 —Same case (lateral vi w bronchogram) Arrow mark lateral bronchu of middle lobe Medial di ision n t fille It was occlude l b a small carcinoma and this segment was small and airless



Fig 85—Atelectasi of the right middle and lower lobes Slight relative hypertranslucency of right lung small spread out lung vessels and small h lar vessels relative to th left



Fig 86—Same cas (bronchogram) Arrow marks intermediate bronchus indicating that both middle and lower lobe branches lie within the opaque area covered by the right side of the heart shadow

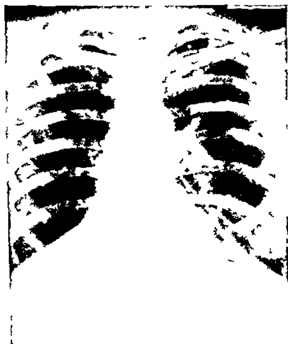


Fig 87—Atelecta is of the right lower lobe Triangular shadow in cardio-phrenic angl Small hilar vessels Aden ma of bronchus Male aged 43 years 7 months ago onset of cough sputum fe er and dyspnoea

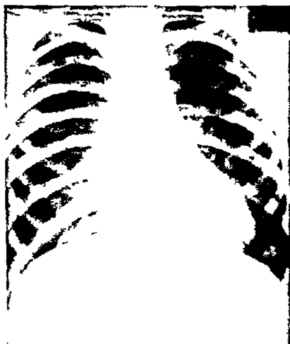


Fig 88—Atelectas s of the left lower lobe Triangular shadow behind heart Sl ght relati e hypertranslucency of lung, small vessels part cularly near hilum and vessels spread out at wider intervals than in the right lung



F 9 Atelectasis of the lingula Faint haze near left hilum M 1 aged 55 ears se eral haemoptyses Carcinoma of lingular bron hu



Fi. 90 —Sam case (lateral view) Arrow marks pos erior conca e border of the opaque shrunken lobe Consolidat n of apical segment of lower lobe also present.

tomographic layer Nor can a lesion even a short way down the lingular bronchus always be seen on bronchoscopy Bronchography may therefore be indicated to prove occlusion if these other tests are negative (Fig 143)

Distinction from consolidation without shrinkage is possible if there is marked forward displacem t of the main interlobar fissure Lingular atelectasis is easily distinguished from the rare interlobar effusion which occurs in the lower part of the main fissure since the lower margin of the shadow of the effusion would be convex posteriorly and would lie posterior to the predicted position of the fissure

Lower lobe atelectasis

Lower lobe bronchostenosis with atelectasis is usually associated with slight elevation of the diaphragm on the affected side and some displacement of the heart towards the affected side If th lesion is on the right side depression of the horizontal fissure can often be clearly recognized On either side an alteration of the hilar vascular pattern can be seen on the affected side (Figs 87 and 88). These changes are often in themselves a sufficient indication for a fuller x ray investigation even when the shadow of the collapsed lobe is not observed

In the anterior view radiograph the emerging main hilar vessels seem smaller than normal This may be more apparent than real due to the fact that at a given site the branches represented belong to the next generation to those normally seen there so that the segmental vessel is mistaken for a lobe branch On the other hand there may be in addition a real decrease in calibre which may be eith r functional or in association with the development of some true emphysema If the lesion is on th right side the normal Y shape of the first branches is lost and if it is on the left side the mid group seems to be missing from its usual position being displaced downwards and simulating the lower lobe group The mid lung vessels are more spread out on the affected side than in a correspondir area on the other side and there is some hypertranslucency of the lung field the appearances bein those of compensatory emphysema

A small opacity obliterating the costo-phrenic recess with a well-defined concave upper marg is a common finding in the anterior view (Fig 91) and results from the retraction of the pleura towards



Fig 91 —Atelectasis of the left lower lobe Owing to the relatively large exposure the triangular shadow is clearly seen through the heart shadow Pleural retraction obliterates the costo phrenic recess



Fig 92 —Same case (left posterior oblique view) The arrow marks the antero lateral margin of the collapsed lobe It was less distinct in the true lateral view and in the left anterior oblique view

the shrunken lobe In a well exposed film the margins of this shadow can be seen to continue medially to join the lateral border of the classical triangular shadow of the shrunken lobe which lies for the most part behind the heart shadow This lateral border runs upwards and inwards in an almost straight line from the diaphragm to the hilum The triangular shadow may be visible through the heart shadow in a routine anterior view but usually an additional radiograph taken with greater exposure is needed before it can be seen The high exposure anterior view radiograph is often a more effective way of showing the opaque lobe than a lateral view in which it can often only be identified with difficulty It can however be shown clearly in lateral view tomographs or in a left posterior oblique view plain film taken with the patient rotated 45 degrees (Fig 92)

When the lobe shrinks to a very small size the shadow is less triangular The lateral border may run almost vertically downwards close to the vertebrae and may show a slight convex bulge This shadow may be so small or so completely superimposed on the shadow of the vertebrae that it cannot be seen even in a well exposed anterior view It can then be shown in a well exposed posterior view tomogram which will also demonstrate the occlusion and displacement of the lower lobe bronchus as well as the altered vascular pattern

Commonly the triangular shadow of a shrunken lobe is seen but no bronchostenosis is demonstrated on tomography bronchography or bronchoscopy There is often no evidence then to show whether the condition resulted from a bronchostenosis which is no longer present or whether it is a post inflammatory contraction with bronchiectasis without present or previous narrowing of the main lower lobe bronchus

On the right side the underlying lesion which caused the collapse of the right lower lobe may also have blocked the middle lobe bronchus so that the resulting shadow includes both middle and lower lobes (Fig 85) Isolated right lower lobe collapse can only be diagnosed if the horizontal fissure can be seen—this is usually depressed and slopes downwards and outwards Failure to see the fissure may mean either that it is absent or invisible or that both lower and middle lobes are collapsed and the fissure is forming the lateral border of the resulting triangular shadow The size of the shadow is no guide since it may be very small even when both lobes are involved In a bronchogram the middle

shadow is seen running forwards just above the expected position of the horizontal fissure while the inferior concave curve of the lower margin is particularly well seen (Fig. 94).

Collapse of the anterior segment of the left upper lobe results in a rather shorter band like shadow lying at a somewhat higher level. The inferior margin borders on the lingula so that it is less well defined and the segment tends to retract towards the hilum so that the shadow is shorter than with a lesion of the same segment on the right side.

Frequently, particularly when the stenosis is due to a bronchial carcinoma, both the anterior and posterior segments of the right upper lobe are collapsed (Fig. 82).



Fig. 93.—Atelectasis of the anterior segment of the right upper lobe. The band like shadow has an inferior concave margin formed by the raised horizontal fissure and is seen meeting the fifth rib in the axilla. There is no elevation of the right dome. Male aged 54 years. Two months haemoptysis. Fell within a ... old. Neoplasm visible on bronchoscopy.



Fig. 94.—Same case (lateral view). Arrow marks line of main fissure clearly seen in the original radiograph. The band like shadow with the inferior concave lower margin is formed by the airless segment. Specimen showed a [illegible]-centimetre bronchial carcinoma occluding anterior bronchus. Lung distal to this was airless. Very little other change except some oedema and mucus distended bronchi in the lower half.

Atelectasis of the posterior segment of the right upper lobe

Collapse of the posterior segment of the right upper lobe distal to a stenosis of the segmental bronchus results in a ½–1 centimetre band like shadow with a well-defined posterior margin against the line of the upper end of the main fissure (Fig. 82). The anterior superior margin is often less well defined. The shadow is more easily seen in a lateral view than an anterior view and in a lateral view tomogram than in a plain lateral view radiograph.

Atelectasis of the medial or lateral segment of the middle lobe

Collapse of the medial segment of the middle lobe from stenosis of the segmental bronchus is uncommon but is sometimes seen. In the anterior view there may be no obvious abnormality on the plain radiograph or there may be slight depression of the horizontal fissure and a faint haze in the lower zone adjacent to the heart. In the right lateral view a linear or band like shadow may be seen running downwards and forwards suggesting atelectasis of the whole of the middle lobe. The diagnosis will be suggested if some aerated lung can be seen between the shadow of the airless part of the lobe and

the horizontal fissure (Fig 81) It may be confirmed on bronchography At a superficial glance the bronchogram may appear normal with filling of the middle lobe but on closer inspection it will be seen that there are too few divisions of the middle lobe bronchus in the lateral view bronchogram (Fig 84) Inspection of the anterior view bronchogram will show the lateral branch of the apical lower lobe segment quite clearly which will indicate the site of the origin of the middle lobe stem A lateral division (of the middle lobe) may then be traced downwards and outwards from this but it will then be obvious that the medial division running close to the right heart border is absent (Fig 83) Sometimes a short column of the contrast medium will fill the proximal part and then the obstruction will be clearly shown The cardiac bronchus comes off the main intermediate stem bronchus at a lower level than the apical lower lobe bronchus so that it will not be mistaken for the medial segmental bronchus of the middle lobe

Collapse of the lateral segment of the middle lobe may give a similar appearance in the plain radiographs and in the lateral view bronchogram but in the anterior view bronchogram the medial division will be seen running downwards close to the heart border but there will be no lateral branch originating at the same level as the lateral branch of the apical lower lobe bronchus

Atelectasis of the apical segment of the lower lobe

Collapse of the apical segment of the lower lobe distal to stenosis of the apical lower lobe bronchus is generally associated with so much distal inflammation that the x ray appearances suggest consolidation Sometimes the segment shrinks to a sufficiently small size to give a band like shadow which is best seen in a lateral view The segment tends to swing downwards so that it runs backwards almost horizontally at a rather lower level than the normal position of the apex of the segment

Atelectasis of a basal segment

Collapse of a basal segment in isolation due to stenosis of a basal bronchus is unusual presumably because it remains well aerated by cross aeration Small triangular shadows from such a bronchostenosis are generally the result of bronchiectasis and inflammatory changes rather than collapse The lateral division may become occluded and cross aeration interfered with because of poor diaphragm movements so that the lateral division of a segment collapses and produces a band like shadow just above and parallel to the diaphragm

CIRCULAR OR OVAL HOMOGENEOUS INTRAPULMONARY SHADOWS

The shadows under this heading range from pin point size to a size of several centimetres They may be very well defined evenly circular or evenly oval or rather lobulated or they may be poorly defined and perhaps not even regularly circular or oval Included in the category are single isolated shadows multiple shadows of similar size and shape and multiple shadows of dissimilar size and shape

A Single Large Circular or Oval Shadow

A single large circular or oval homogeneous shadow may have been first observed when it was only a few millimetres in size after which it grew to a much larger size or it may be first observed when it is already a large isolated homogeneous shadow over 2 centimetres in size It may lie anywhere in the thorax and its spacial position can be determined from plain anterior view and lateral view radiographs though not always its anatomical position

If it is deep in the lung and remote from the chest wall or mediastinum its intrapulmonary position is fairly obvious more often however it borders on an interlobar fissure or the peripheral pleural cavity so that it is not always possible to be certain whether the lesion is in the lung parenchyma or whether it arises from the pleura and pushes the pulmonary tissue aside If it reaches the chest wall at any point there is also the possibility that the lesion arises from some structure in this part An example of this would be a neurofibroma arising from an intercostal nerve

If the shadow lies antero medially and reaches the retrosternal region or if it lies medially adjacent to the heart shadow then distinction from a mediastinal lesion may not be easy and may not in fact be possible from plain radiographs or fluoroscopy

If it lies inferiorly the lower border will merge with the shadow of the diaphragm and in an anterior view radiograph the upper border of the tumour may be mistaken for a raised dome of the diaphragm (Fig 95) A lateral view however will reveal its intrapulmonary position although most of the shadow is at a lower level than the upper border of the right dome anterior to it (Fig 96) There may be aerated lung right round it but if it rests on the diaphragm none will be seen inferiorly

The diaphragm is often normal and there is usually no displacement of the heart trachea interlobar fissures or nearby vessels The presence or absence of local changes in the ribs or vertebrae should be noted

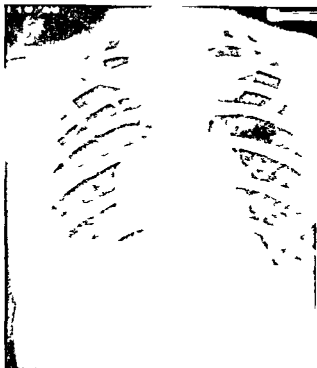


Fig 95 —Secondary deposit in the right lower lobe simulating a raised right diaphragm Also deposits in right hilum region Haemoptysis so chest radiographed Later found to have a primary sarcoma of the pelvis

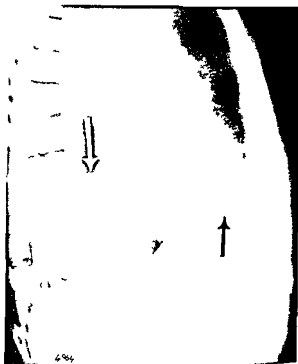


Fig 96 —Same case (lateral view) White arrow points to circular shadow of the tumour Black arrow to physiological elevation of the anterior third of the right dome Half the tumour lies above this level

When a large circular homogeneous shadow is seen and there are no other obvious abnormal shadows or bone changes then the list of possibilities is formidable It may be possible to make a diagnosis on clinical grounds if for instance a primary neoplasm is found elsewhere if tubercle bacilli are found in the sputum or if the Casoni test for hydatid disease is positive Frequently however there are no such clues so that any further evidence obtainable from the radiological appearances will be of help The presence of other intrapulmonary shadows should be sought if necessary with the help of tomography since the demonstration of small satellite shadows short linear or ring shadows and perhaps calcifications will suggest tuberculosis whilst small contra lateral circular shadows would suggest secondary deposits and exclude a benign tumour or developmental aberration which with the exception of an arterio venous aneurysm are generally single Any large circular shadow may develop near old calcified tuberculous lesions and more active tuberculous lesions could theoretically coexist with one of the large homogeneous circular shadows of a non tuberculous origin but in point of fact neither of these combinations is at all common

A remote bone erosion would suggest a secondary deposit so that a careful inspection of the bony parts is indicated A local bone erosion adjacent to a large oval shadow is sometimes seen with a primary bronchial carcinoma usually in the apex though sometimes lower It may be indistinguishable from a primary malignant bone tumour or from a secondary deposit in the bone with a soft tissue extension of the neoplastic mass beyond the limits of the bone and encroaching on the lung field

In a large number of cases there are neither clinical nor radiological clues as to the nature of the large circular shadow and a final diagnosis can only be made after serial x ray examinations at a thoracotomy or at a subsequent histological examination of the lesion

The following section deals with the different lesions that may be finally diagnosed in cases in which a large homogeneous oval or circular shadow similar to that in Figs 97 and 98 is seen on the radiograph In each group at least one example has been encountered by the author Pathological confirmation was obtained in all but the acute infective lesions for which only clinical and the serial radiographic evidence was available



Fig 97 —Bronchial carcinoma in the l ft lung The shadow is quite well defined roughly oval and slightly lobulated



Fig 98 —Same case (lateral view) Most of th neoplasm lay in the upper lobe but had transgressed the fissure

Common causes of a large circular or oval homogeneous shadow

Bronchial carcinoma

Bronchial carcinoma is at present by far the most common cause of an isolated fairly well defined circular shadow in an elderly male (Figs 97 and 98) It may be found on mass or incidental radiography of the chest but more often the radiograph is taken because of the usual symptoms of this condition The shadow may be well defined but is rarely quite as well defined as the shadow seen in some cases of bronchial adenoma an isolated pulmonary secondary deposit or a hydatid cyst Quite often the shadow of a bronchial carcinoma has a rather hazy margin without actually appearing to infiltrate out into the surrounding normal lung Although it may be regularly circular in shape it is often a little flattened in parts so that it appears like a rather rounded square It not infrequently shows a localized bulge or may be distinctly lobulated while sometimes one edge of the circle is less well defined than the rest

A secondary deposit

A secondary deposit in the lung may be single and grow to a large size It is usually particularly well defined perhaps more so than most primary malignant neoplasms An intravenous pyelogram may reveal a clinically silent renal neoplasm but for neoplasms in other sites there are often no radiological clues to the diagnosis The shadow may first appear many years (sometimes as many as 20 years) after the removal of a known primary neoplasm

A hydatid cyst

A hydatid cyst is more easily diagnosed if the possibility of this condition is borne in mind It is usually very well defined oval in shape and may be lobulated It may lie deep in the lung or one margin may reach the pleural surface it is usually in the lower half of the lung

A toruloma

A toruloma (fungus infection—*Cryptococcus neoformans*) is also a cause of a large oval or circular well defined homogeneous shadow The lesion may be clinically silent and only discovered on mass or incidental radiography of the chest The shadow is generally mistaken for a carcinoma and the diagnosis in some cases is only made after its removal by lobectomy or pneumonectomy In other cases there may be a productive cough and the fungus may then be found in the sputum if it is present in reasonable numbers and if it is sought Sometimes there is also an intracerebral lesion and the neurological manifestations of this may predominate



Fig 101 —Mycetoma right apex Arrow points to the halo shadow produced by the small translucent air space between the wall of the lesion (consisting of fibrous tissue) and the central mass (consisting of aspergilli mycelia) Male aged 48 years Mass x ray finding Aspergilli grown from sputum Lobectomy performed

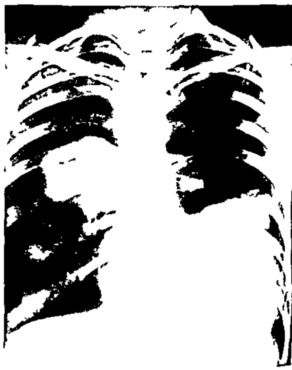


Fig 102 —Hydatid cysts in the lungs The cyst in the left lower lobe was infected The smaller cyst on the right was situated in the posterior part of the upper lobe Female aged 35 years Recent left pleurisy Both cysts removed with good recovery

In one case the radiograph showed a 6 centimetre oval shadow in the right lower zone and section of the lung revealed a 6 centimetre oval well defined grey soft mass On histological examination this was found to be due to a form of chronic pneumonia and contained cryptococci in large numbers lying mainly in the alveoli

A mycetoma

A mycetoma (another fungus infection—*Aspergillus fumigatus*) is less silent clinically and the fungus may be found in the sputum When this is so it is still difficult to say whether it is a late secondary invader of an infarct cyst bronchiectatic dilatation or chronic tubercular cavity or whether it is a true primary cause of the lesion The finding of tissue invasion on histological study would favour the last hypothesis The shadow may be well defined and quite homogeneous or it may show a narrow zone of translucency just beneath the outer margin producing a halo shadow (Fig 101)

Section of the lobe after removal revealed a central pink gelatinous mass with a small air space between it and a smooth fibrotic cavity wall The central mass was full of aspergilli mycelia and there was no evidence that it represented a blood clot The cavity wall in which this mass lay was fibrotic and careful dissection failed to indicate how it had been formed

An infarct

An infarct may have a circular form but if it is larger than 2 centimetres the clinical picture is usually obvious

A syphilitic lesion

A gumma may present as a 2–4 centimetre circular shadow—some have been removed on a mistaken diagnosis of a neoplasm They are rather rare and often the diagnosis is uncertain even after removal In one of the author s cases the histology was suggestive of this diagnosis but serological tests were inconclusive

A non specific granuloma

A granulomatous mass whose aetiology is uncertain even after removal adds yet another difficulty to the many difficulties connected with the interpretation of these large and very obvious circular or oval x ray shadows

Multiple Large Circular or Oval Homogeneous Shadows

Multiple large circular or oval homogeneous shadows are produced by secondary deposits or hydatid cysts (Fig 102) Differentiation may be possible on clinical grounds while the presence of other much smaller shadows on the radiographs would suggest secondary deposits

Two hydatids of almost equal size may be seen in either lower zone of the lung (Fig 102) a distribution which would be unlikely to occur with secondary deposits

Multiple hydatid cysts are usually of the same age and of similar size Occasionally the growth of one is arrested while the other grows to a larger size If the two are close to each other and the larger one becomes infected and loses its clear cut outline the diagnosis might be in doubt especially if the smaller well defined circular shadow is blurred by the nearby inflammatory changes In such a case a tomogram would usually show the smaller shadow clearly and would therefore confirm the diagnosis

Another combination of shadows which may very occasionally be seen is a particularly well defined shadow lying posteriorly for example a neurofibroma and another rather less sharply demarcated shadow probably in the other lung which may be a bronchial carcinoma or an intrapulmonary secondary deposit from an extrathoracic primary neoplasm The presence of the long standing neurofibroma may be known from a previous radiograph but more often it is clinically silent and only found as a result of symptoms arising in connexion with the malignant neoplasm

A Single Small Circular Homogeneous Shadow

When a small sized low density shadow is seen it is particularly important to make sure if it is in the lung and not an artefact Unless it can be clearly identified in a lateral view its position should be fixed by means of tomography Tomograms would also show any satellite shadows or other abnormal features such as unsuspected cavitation calcification or abnormal vessels in connexion with the shadow

A list of causes of a single small discrete circular low density homogeneous shadow (between 2 millimetres and 2 centimetres in size) will obviously include early examples of all the pathological lesions just quoted for larger shadows but as detection at this early stage is uncommon the emphasis will be different

A tuberculous lesion

Tuberculosis will be by far the most common finding Three distinct pathological entities have been found all showing an appearance identical with that in Fig 103 First there is the small focus of tuberculous pneumonia This may be found at various stages at a fairly early exudative and pre caseous stage at a proliferative stage at a caseous stage—with the ghosts of the lung structure well

HORIZONTAL LINEAR SHADOW ABOVE THE DIAPHRAGM

A transient shadow some 1–3 centimetres long and 2–5 millimetres wide is seen quite frequently lying horizontally 1–3 centimetres above the diaphragm Such a shadow has been described as a Fleischner s line or as a linear or plate like atelectasis Because of the difficulties of correlating these shadows with the morbid histology they have acquired more importance than their clinical significance merits They nearly always resolve in a matter of days or months and do not in themselves give rise to symptoms In some cases the line is undoubtedly due to a local pleural condition in others it is definitely within the lung In many other cases it is caused by a mixture of the local pulmonary lesion and some pleura drawn towards it The morbid histological findings often reveal a narrow zone of airless alveoli some with fluid in them, and some just incompletely expanded or collapsed. The more chronic lesions show some fibrous tissue and some indrawn thickened pleura

Such a line shadow is seen quite often in a radiograph of the chest taken a day or two after an abdominal operation The poor movement and high position of the diaphragm may have contributed towards the pathological changes in these cases since they render cross aeration inefficient which in turn would allow any excess of local secretion in a small peripheral bronchus to result in a limited area of atelectasis Similar factors may account for the line shadow sometimes seen during the stage of resolution of a basal inflammatory lesion Many such horizontal line shadows are the result of a thrombo embolic infarct the presence of which is obvious clinically The line shadow resulting from a small infarct usually disappears within 3 months

HORIZONTAL LINE SHADOW ABOVE THE COSTO PHRENIC RECESS

Another rather smaller line shadow is that frequently seen lying more laterally just above the costo phrenic recess (Fig 112) It may be single but often there are three or four parallel line shadows at intervals of about 5 millimetres They vary in length from ½ to 2 centimetres and are generally present on both sides Some reach the pleural surface and others appear to bifurcate before reaching the periphery They are seen in a variety of conditions and morbid histological correlation with the radiographs has revealed the following causes

A dilated lymphatic channel is a common cause especially in mitral stenosis The line shadow in Fig 112 could definitely be attributed to a large dilated lymphatic lying directly beneath the visceral pleura which was very conspicuous at thoracotomy Similar radiographic appearances and morbid histological findings are seen in lymphangitis carcinomatosa the lymphatic being dilated and obstructed and often full of carcinoma cells

Another cause of a small line shadow just above the costo phrenic recess is a thickened interlobular septum Both the lymphatics and veins run in the interlobular septa so that if either are engorged the septa may become oedematous this is not infrequent in mitral stenosis In one case an autopsy examination showed no evidence of dilatation of the lymphatics but did reveal very conspicuous thickened interlobular septa the direction and position of which corresponded to the line shadows seen in a radiograph taken 2 days previously There was some vessel engorgement as a result of the mitral stenosis The line shadows were very similar to those shown in Fig 112 The shadow of the septum may be made even more conspicuous by haemosiderin deposits in or around it Thickening of the interlobular septa may account for similar line shadows seen in some cases of emphysema and some cases of pneumoconiosis

A third cause of these line shadows is engorgement of the peripheral vessels which is also seen in some cases of mitral stenosis In certain very thin normal persons even the normal vessels may be visible in this region and appear as line shadows Vascular shadows can be distinguished from shadows due to other causes as they can generally be traced back towards the hilar where their connexion with other indubitably vascular shadows will be obvious

BAND LIKE SHADOWS

Band like shadows 2 millimetres or more in width may have truly parallel walls or be rather elliptical in shape or have an enlarged peripheral end—the gloved finger shadow

A band like shadow with parallel walls is often caused by a pleural lesion and is a wide version of one of the pleural line shadows mentioned above Wide band like shadows are seen particularly with

adhesions in a pneumothorax They are also seen in consolidation or collapse of some of the segments of the lung particularly the anterior and posterior segments of the upper lobe (Figs 82 and 94)

Band like shadows are occasionally seen traversing very large cavities or bullae They represent trabeculae or remnants of a vessel passing through the air space

A short band like shadow close to the hilum may be caused by an inhaled foreign body (such as a piece of bone) lodged in one of the larger bronchi

A band like shadow 3–8 millimetres wide which tapers and bifurcates as it passes distally may be caused by a group of mucus filled bronchi associated with a developmental defect of that part of the lung A very similar shadow may be caused by an anomalous vessel and its branches associated with a partially sequestrated segment in which the surrounding lung is aerated In either case the surrounding aerated lung may have a bullous appearance with absence of the normal vessel shadows Tomograms may reveal the hilar connexions of the band like shadow and hence its venous or arterial nature (Fig 113)



Fig 113 —A band like bifurcating shadow (marked by arrows) The shadow was due to an anomalous vessel in an abnormally developed part of the left upper lobe Male aged 33 years One small haemoptysis Nature was uncertain until resection



Fig 114 —Tubular shadows at the left base due to bronchiectasis (one is marked by the arrow) Well-exposed radiograph Child aged 10 years with cough and sputum Bronchogram confirmed dilated bronchi in rather shrunken left lower lobe

In the condition in which there is an anomalous venous drainage into the heart the dilated normal or supplementary vessel may also cast a long wide band like shadow Tomograms will show the band like character of the shadow more clearly than the plain radiographs a study of the shadow in successive layers will show its course and whether it is first connected with other pulmonary veins or the azygos vein or whether (and where) it has a direct point of contact with the heart shadow

The dilated vessels leading to and from an arterio-venous aneurysm in the lung may be seen as band like shadows some 3 6 millimetres wide and these may be an even more conspicuous feature than the shadow of the aneurysm where the anastomosis occurs (Fig 104)

A large artery to a sequestrated segment may also cast a band like shadow This may be traced into one of the hilar vessels or if it originates from the thoracic or abdominal aorta it may get lost when it reaches the central shadow or the diaphragm The segment itself if not aerated will be seen as a circular or oval homogeneous shadow

An elliptical homogeneous shadow is seen in some cases of middle lobe bronchostenosis and in an interlobar effusion (*see* p 27)

Gloved finger shadows are often seen in bronchiectasis which is by far the commonest cause of such a shadow Rarely a group of caseous tuberculous pneumonic foci may have an elongated shape and thus give rise to a similar shadow In bronchiectasis the gloved finger shadows may be crowded together suggesting some lobar shrinkage which may be confirmed in a lateral view by visible displacement of an interlobar fissure The presence of tubular shadows nearby will indicate both shadows are due to dilated bronchi the one filled with secretions the other containing air

In children a low grade left basal inflammatory lesion quite often results in shadows which are very similar to the gloved finger shadows seen with bronchiectasis Since cough and sputum may be present in a pneumonia bronchiectasis may be mistakenly diagnosed The partial consolidation of a pneumonia will generally resolve within weeks and the disappearance of the shadows together with the improvement in the clinical picture will often suffice to dispel the fear of bronchiectasis

TUBULAR SHADOWS

A tubular shadow consists of two roughly parallel line shadows between 1–4 millimetres wide surrounding a central translucency of somewhat similar width It is usually caused by a dilated bronchus and is therefore directed towards the hilum An isolated tubular shadow may also be caused by two normal vessels perhaps situated on quite different planes running parallel to each other for a short distance Such normal vessel shadows if traced farther will be seen to taper bifurcate and separate and are thus easily distinguished from the shadow of an abnormal bronchus In bronchiectasis there are *generally several tubular shadows lying close together in a lobe like gloved finger shadows* they are often associated with evidence of some lobar shrinkage

Tubular shadows due to dilated bronchi especially if they lie behind the heart shadow may be indistinct or even invisible in a routine anterior view radiograph but may nevertheless be clearly seen in an additional radiograph taken with greater exposure (Fig 114) They may also be clearly seen in a lateral view or in well exposed tomograms Dilatation of the proximal branches is often associated with occlusion of the more distal ones so that the abnormal tubular shadows do not extend as far distally as do the normal bronchi and the shadows end some 2–3 centimetres above the diaphragm In other cases the more peripheral branches are also dilated in which case the abnormal shadows extend farther distally In the case of bronchiectasis of the left lower lobe these dilated peripheral branches may be visible against the superimposed air translucency of the stomach, whereas in a lightly exposed routine anterior view radiograph the more proximal dilatations cannot be seen through the general opacity of the heart behind which they lie

Tubular shadows are often associated with small areas of patchy clouding around them due to inflammatory changes in the nearby alveoli or with areas of hypertranslucency with vessel narrowing due to local emphysematous changes The air presumably reaches these bullous areas by cross aeration since in a bronchiectasis the very peripheral bronchi are usually occluded

MODERATE SIZED AND LARGE RING SHADOWS

A ring shadow is a roughly circular translucent space surrounded by a relatively narrow zone of opacity *The size of the translucent space varies greatly and so does the width of the surrounding wall* Ring shadows may be single or multiple isolated or in the midst of other kinds of shadow A ring shadow *should always be considered to represent an intrapulmonary cavity* unless an extrapulmonary site is suggested either by some special appearance in the radiographs supplemented when necessary by tomograms or by some special feature in the history or clinical findings

An intrapulmonary cavity is usually the result of destruction of lung tissue and its replacement by air the air space having been initiated in this way may later be ballooned out by a ball valve action of the draining bronchus Another type of cavity is formed by the dilatation of a bronchus or bronchiole as a result of bronchostenosis or of an infection causing erosion and weakening of the bronchial wall Yet another type of cavity is the result of necrosis deep in a neoplasm and finally a cavity may be part of a developmental abnormality

Establishing the Presence of a Ring Shadow

It is of course first necessary to establish with reasonable certainty that a ring shadow is in fact present on the radiograph. An intrapulmonary cavity may be very conspicuous or it may only be seen with difficulty; it is a useful procedure therefore, whenever abnormal shadows are seen, to try and conjure up the image of a ring shadow amongst them. This may be partly obscured by superimposed or surrounding areas of pathological shadowing or by the superimposed shadows of normal structures such as the hilum, the heart, a rib, the clavicles or the apex of the diaphragm. A cavity of this sort will be difficult to see in a single anterior view radiograph and may be more easily identified on fluoroscopy since it may become more conspicuous on slight rotation of the patient. Alternatively it may only be demonstrated in a lateral view or with greater certainty by tomography. The indications for tomography and the features in a tomogram which will suggest the presence of a cavity are discussed on page 149.



Radiographic Appearances of the Lumen and the Cavity Wall

Although a ring shadow is usually evenly circular or oval, the wall may have excrescencies into the interior so that the lumen is very irregular as in Fig. 115. Sometimes the lumen is even slit like or crescentic in shape. It may be circular and centrally placed with a wall of even thickness; it may be



Fig. 115.—Thick walled tuberculous cavity with irregular projections into the translucent air space. Male aged 44 years. Recent onset of cough and sputum. Tubercle bacilli found. Specimen showed very irregular wall of cavity with liquefaction of a caseous pneumonia and some fibrosis.



Fig. 116.—Thin walled neoplastic cavity. Arrow points to thin wall. Fluid level in lower half. Male aged 40 years. Pains in joints. Dry cough and loss of weight. Right middle lobectomy revealed active and calcified tuberculous glands. Specimen showed wall of cavity consisted of squamous carcinoma cells.

eccentric in an otherwise circular shadow; or it may be placed almost anywhere within an irregularly shaped diffuse shadow, the size of which will indicate the amount of surrounding consolidation. This may occupy a whole lobe or only part of a segment, and there may or may not be evidence of shrinkage of the lobe due either to the cavity and surrounding lung lesions or to an underlying bronchostenosis.

The word "ring shadow", used in reference to the radiographic appearances of an air-containing cavity, is therefore given considerable latitude.

The thickness of the wall which forms the boundary of the cavity is also very variable, and is a feature which is sometimes of help in the diagnosis. A ring shadow with a wall of hair line width is much

the end of expiration Alternatively complete obstruction or renewed free patency of the draining bronchus may be a factor in the rapid closure of the cavity and consequent disappearance of the ring shadow

The cavity wall is usually much less well defined histologically than it appears in the radiograph A zone of oedematous alveoli or compressed (condensed) airless alveoli is often found around the wall and variations in the width of this zone may account in part for the changes in the apparent thickness of the wall sometimes noted in serial radiographs

Infective Cavities

An infective cavity or lung abscess may be due to a specific non tuberculous infection such as a staphylococcal pneumonia or to mixed organisms as in suppurative pneumonia In the acute stage with perhaps a gangrenous area of lung the wall will consist of pneumonic consolidated or necrotic lung tissue In the subacute or chronic stage the wall will be formed for the most part by granulation *tissue with some surrounding consolidated or oedematous alveolar spaces If it becomes chronic* fibrotic tissue will be present in increasing amounts

The x ray appearances of an infective cavity whether due to a specific coccal infection or to a mixed infection are very variable depending to some extent on the stage of the abscess and on the degree of surrounding consolidation In the early acute stage of a lung abscess the only evidence of cavitation may be a small translucent zone with or without a fluid level lying in a well defined 2–3 centimetre circular shadow (which may have quite a well defined margin) or in an area of opacity indicatin consolidation of the greater part of a lobe or segment Rather later the central air translucency enlarges and becomes more obvious as some of the fluid is coughed up through the draining bronchus The size of the fluid level depends on how well the cavity is draining The anatomical site of the lesion can also be determined from the radiographs

Resolution may proceed quite rapidly the fluid level vanishing and the ring shadow getting smaller and in its turn becoming invisible on the plain radiographs though persistence of a ring shadow for some time longer may be shown on tomograms If the abscess becomes chronic the wall becomes thinner and better defined so that a typical ring shadow with a wall some 5 millimetres wide will be clearly seen As healing proceeds the wall becomes thinner and if the cavity persists it will become virtually a post infective cyst with a well defined wall no thicker than 1–2 millimetres consisting almost entirely of fibrous tissue (Fig *118*)

In a staphylococcal pneumonia particularly in a child quite a large air space may appear in the opaque consolidated area in a matter of hours often in the absence of much sputum so that there is no evidence of expectoration of either necrotic lung tissue or of the pus from an abscess The exact mechanism of production of these acute cavities is unknown but it is always assumed they are tension cavities arising as a result of the acute inflammation producing a ball valve action of the bronchus They are quite common in a staphylococcal infection and uncommon in infection due to other organisms They may be single and the consolidation confined to a lobe or part of a lobe or they may be multiple either in close proximity to each other or scattered as small foci in several lobes a distribution seen with embolic abscesses in staphylococcal septicaemia In the early stages a fluid level is quite common whilst if they do not resolve as the infection subsides the cavity will usually fill on bronchography if this test is carried out

After the pneumonia has subsided which may be within a few days the cavity may also shrink and finally disappear Quite frequently however a ring shadow or several ring shadows with a hair line thick wall remain indefinitely and are often symptom free for long periods thereafter (Fig 118)

A single large residual ring shadow some 2–5 centimetres in diameter with a wall only 1–2 millimetres wide will suggest that the abscess has become a post infective cyst the wall of which may *consist mainly of fibrous tissue The exact anatomical site (bronchiole or alveolar) is generally unknown*

Fungus Infection with a Cavity

In aspergillosis a well defined ring shadow may be seen with the fungus mass occupying most of the lumen as in Fig 101 In other cases a 2–5-centimetre translucency is seen in an ill defined area of clouding the appearances simulating a chronic lung abscess The finding of *Aspergillus fumigatus* in

the sputum will suggest this diagnosis of the ring shadow but the relation of the cavity to the fungus must be assessed with caution Histological study of the wall of the cavity after resection may indicate that it is a distended bronchus a cyst or an infarct breaking down so that the aspergilli seem to have been a secondary invader On the other hand if the fungus is found to have invaded the wall and nearby lung it will appear to have been the primary cause of the cavity Sometimes the history and previous radiographs indicate that the fungus is a secondary invader of a pre existing tuberculous cavity

The advent of the fungus infection superimposed on a chronic tuberculous cavity (possibly sterilized by a long course of chemotherapy) is sometimes shown in the radiograph by a sudden increase in the thickness of the wall from a few millimetres to well over 1 centimetre

In coccidioidomycosis a fine 1–2 centimetre ring shadow is often seen particularly in the mid zone It usually has a thin well defined wall and a fluid level may be present The wall consists of granulation tissue with giant cells and fungi in it At a later stage it may become fibrotic The condition is found in the United States of America The radiographic appearances simulate those of tuberculosis but the bacteriological and serological findings will generally indicate the diagnosis

In histoplasmosis a thin walled 1–2 centimetre cavity is also sometimes seen This form of the disease has not yet been reported in persons who have not at one time or another been in an area where the disease is endemic Distinction from a tuberculous cavity can only be made on the clinical findings

Parasitic Infection with a Cavity

The cavity seen after a hydatid has been coughed up (or removed) will appear the same as a lung abscess The wall may be quite well defined but often the margins are indistinct so that it suggests an abscess with much surrounding consolidation Histological examination may reveal the special features found in this condition If no clinical clues are present and the cavity boundaries poorly defined then the diagnosis may be difficult unless previous radiographs showing its good definition before rupture are available or tomograms show a small well defined homogeneous shadow from another previously unsuspected cyst

Dilated Bronchus

A ring shadow due to a single dilated bronchus may be seen in one form of non tuberculous bronchiectasis The wall will have the structure of a bronchus and the appearances on the radiograph will be the same as those of a post infective cyst or other cause of a well defined thin walled ring shadow It may attain a size of several centimetres

Much more commonly several bronchi are dilated the resulting ring shadows being about ½–2 centimetres in diameter (Fig 150) They may be situated in one lobe or the distribution may be quite widespread The ring shadows are usually quite conspicuous but if they lie medially so that the hilar shadows are partly superimposed on them they may be obscured in an anterior view though clear enough in a lateral view or in tomograms This form of bronchiectasis with localized ring shadows is sometimes seen in elderly patients with symptoms suggesting chronic bronchitis

In a third form of cystic bronchiectasis there are widely diffused ring shadows the walls of which are of hair line thickness This appearance is sometimes referred to as cystic lung There may be few or no symptoms and no other changes on the plain radiographs If fluid levels are present in these cystic bronchiectases a half moon shadow may be seen occupying the lower part of each ring shadow which may be a more conspicuous feature than the ring shadow itself

The presence of ring shadows should lead to a consideration of bronchography but in the absence of specific indications for this (*see* p 139) the diagnosis can often be made from the plain radiographs or from tomograms even though these will not show the extent and character of the dilatations as clearly as the bronchograms

Neoplastic Cavities

In a bronchial carcinoma a lung abscess distal to the growth is not uncommon and will have the same pathological features as a lung abscess due to other causes If the neoplasm is small and near the hilum it may be invisible in the plain radiographs in which case the only visible abnormal shadow will be that of the distal abscess

In rare cases the calcified tuberculous focus may be directly related to the symptoms A recurrent haemoptysis may occur for instance because a calcified lesion is eroding a vessel or being extruded into a small bronchus It is essential to exclude other causes of haemoptysis as far as possible before assuming the calcified focus to be the cause

The combination of a solitary pulmonary calcified focus with calcification of the hilar gland in the region of its drainage is evidence of a tuberculous infection in the past (Gohn s focus) though an identical appearance may be seen in histoplasmosis The shadows should not be dismissed without careful inspection since a discrepancy between the position of the pulmonary focus in relation to that of the gland would indicate the possibility of some displacement of the focus and in some cases this might be the most obvious evidence on the plain radiograph of a lobar displacement from an old bronchostenosis

Calcifications in large circular shadows

Calcifications are sometimes seen in a large 2–4 centimetre low density shadow If the lesion is tuberculous whether a healing primary focus or a massive post primary focus the calcifications are sometimes in the form of narrow concentric rings In some cases only a small central spot of calcification can be seen in the large shadow and in others a fairly large central calcification rather shapeless and either woolly or homogeneous in texture These appearances are sometimes seen in a hamartoma or a dermoid

Calcifications in cavernoliths and broncholiths

If a calcification is seen to be superimposed on a ring shadow in the anterior view a lateral view and if necessary tomograms are indicated to see whether it represents a calcified body (cavernolith) in the cavity or another focus remote from the cavity Anterior views taken with the patient first sitting and then lying on one side and with the x ray beam horizontal will show whether the dense shadow moves in relation to the cavity wall and is therefore lying loose in it or whether it bears a constant relation to the wall and is therefore embedded in or adherent to it The presence of a cavernolith will suggest that a thoracoplasty is not the most suitable method of encouraging cavity closure if some other equally safe method is available

The relation of a calcification to any nearby major bronchus can be determined by tomography and if it is found to be intraluminal it is a broncholith Such a finding might explain an otherwise obscure haemoptysis or series of febrile respiratory episodes A broncholith may be a cavernolith on its way out towards the trachea or part of a calcified tuberculous gland which has ulcerated through the wall and has finally been extruded into the lumen of the bronchus alternatively it may have arisen in its present position as a result of a localized tuberculous bronchitis

Hilar gland calcifications

Calcifications in the hilar glands may be obvious or may pass undetected on the plain radiograph A large group of paratracheal calcified glands may be invisible in the routine anterior view though clearly seen in a radiograph taken with more exposure or in the lateral view Slight degrees of calcification can often be seen only in tomograms whether they are in the lungs the hilar glands or the paratracheal glands This fact must be remembered when only plain radiographs are being used for epidemiological studies or when bronchostenosis is suspected which may possibly be caused by a tuberculous and perhaps calcified gland

Calcifications in small non tuberculous foci

The calcifications in the lungs in histoplasmosis and those in rheumatic fever with or without evidence of cardiac involvement have been described on page 72

Calcification can occur in scars due to non tuberculous inflammation or around fibrotic nodules which have been caused by the inhalation of silica containing dust Some of the nodular calcifications often seen in the upper zones of the lungs may belong to this category but proof that the originating lesion was non tuberculous is often unobtainable A very common cause of fibrotic nodules is chronic bronchitis with emphysema but these scars do not usually calcify A healed infarct may eventually calcify but no proved example of this has come to the author s notice

Calcifications in the tracheal and bronchial cartilages and the pulmonary vessels

Calcifications in the tracheal rings or cartilages of the main bronchi are sometimes sufficiently marked in elderly people to cast shadows in the radiograph The distribution of the calcium is patchy but the general position of the shadows is such that their nature can be readily appreciated A part of the left main bronchus may be seen as a dense tubular shadow which may simulate a vessel calcification

Radiographs of resection specimens of the lungs often show a few small spots of high density shadowing which are due to calcified deposits in the more peripheral bronchial cartilages but these are rarely detected in the routine chest radiographs

Calcifications in the pulmonary arteries within the lung fields are uncommon and rarely diagnosed

Haemosiderosis

In haemosiderosis iron particles from the blood stream are deposited in the lung tissues This may occur in association with some anaemias especially in children or following small haemorrhages into the alveoli or interstitial tissues

The shadows of the iron particles may be of pinpoint size and so numerous that the general effect is that of ground glass So much of the x ray beam may be absorbed that the radiograph appears under exposed even when a standard exposure is given In other cases the shadows are rather more widely spaced and larger reaching a size of 1–2 millimetres In still other cases they may be so sparse and small that they are inconspicuous and can only be seen with certainty with the aid of a magnifying glass they are most easily identified in the periphery of the mid zones

The high density of the shadows may not always be obvious probably because many small deposits at quite different levels are superimposed so that the image of each is rather blurred

The x ray appearances of haemosiderosis in association with mitral stenosis are described on page 111

Pleural Calcifications

A pleural calcification may be small and quite localized resulting in a dense vertical linear or narrow band like shadow usually just above a costo phrenic recess A more elliptical shadow may be seen if the calcification is in the residue of a fibrin body produced during an artificial pneumothorax refill

A dense mottled shadow extending over a considerable area (Fig 119) is a characteristic appearance of calcification in a sheet of thickened pleura On fluoroscopy the position of the shadow just beneath the ribs is easily confirmed Such a shadow is usually asymptomatic and found by accident and generally indicates an old tuberculous pleurisy which may not however be completely sterile In one such case (Fig 119) the shadow had been present for 20 years before the development of a small chest wall abscess made treatment necessary Examination of the specimen after resection of the abscess and thickened pleura revealed several active caseous foci adjacent to the pleural calcifications Similar calcification of a sheet of thickened pleura can result from a traumatic haemothorax or an old partly inspissated non tuberculous empyema

Calcifications in Mediastinal Structures

Extrapulmonary calcifications in mediastinal tumours are described on page 116 those in the pericardium on page 103 and those in the heart and great vessels on page 104

Extrathoracic Calcifications

Extrathoracic calcifications can usually be distinguished from intrathoracic ones if care is taken to locate the position of the shadow accurately from the anterior and lateral views supplemented when necessary by an anterior view taken on expiration by fluoroscopy with careful rotation of the patient or by tomography A tangential view may be useful to confirm some point seen during fluoroscopy

Unusual calcifications in a rib or costal cartilage are possible sources of confusion but these will be seen to bear a constant relation to the rib during respiratory movements Their relation to the rib can if necessary be clearly demonstrated by tomography

A calcification in an intercostal space even if it is in contact with the pleura can often be localized by the same means The calcification may be in a lymphatic gland in the lower neck or upper axillary region or it may be in callus around a rib fracture whether spontaneous traumatic or from a cough

with the widespread multiple lesions of chronic bronchitis and emphysema in which condition there is a tendency for further lesions to develop from time to time

The relation of asthma to emphysema is at present of theoretical rather than practical interest Many asthmatic patients develop x ray changes similar to those just described in emphysema the cardio-vascular changes being more prominent than the bullae Sometimes these changes in an asthmatic are described as over inflation the inference being that if the asthma were to be cured the radiographic appearances would return to normal This in fact happens so rarely once marked changes have appeared in the radiograph that any attempt to make a distinction between over inflation and the irreversible changes of emphysema is at present impracticable

In pulmonary ischaemia particularly when it is due to a congenital heart lesion such as pulmonary stenosis the x ray appearances of the lung fields in which the vessels are all small and the background hypertranslucent may superficially resemble emphysema The clinical findings however will clearly indicate a cardiac condition so that confusion between the two will not arise

Relation of x ray appearances to symptoms

The relation of the radiographic appearances to the clinical picture is not always close The patient may be severely incapacitated by bronchitis and emphysema and yet show only inconspicuous or even no radiological abnormalities On the other hand there may be no disability and the patient may not develop any dyspnoea in the near future in spite of gross changes visible in the radiographs

The subject is surrounded with difficulty because of the lack of precision in making the clinical diagnosis and because there is no easy means of measuring the severity of the conditions nor of distinguishing the functional abnormalities from the structural damage The same difficulties arise when correlating the clinical with the morbid histology findings

No attempt can be made to classify general emphysema from the radiographic appearances alon except in so much as they will show whether the cardio-vascular changes or the bullae predominate

Unilateral Hypertranslucency

Over inflation distal to bronchostenosis

Unilateral hypertranslucency may be the result of over inflation of one side when there is a ball valve stenosis of a main bronchus This may be caused by a bronchial neoplasm a tuberculous gland or a foreign body and may be the only x ray evidence of the underlying condition on the plain radiographs The standard anterior view radiograph may appear almost normal—the unilateral hypertranslucency not being always obvious It becomes much more marked in a radiograph taken on expiration partly because the affected side over inflates and partly because the hypertranslucency stands out more conspicuously against the normal side which becomes more opaque as it deflates in expiration The high pressure resulting from the ball valve action may cause the heart and trachea to swing over to the relatively opaque normal side on expiration The vessel pattern may be normal unless the pressure is very high when vessel narrowing and even bullous areas may appear

Idiopathic unilateral emphysema

In idiopathic unilateral emphysema there is no evidence of bronchostenosis neither is the vessel pattern altered in the same way as in emphysema with chronic bronchitis nor are any gross abnormalities visible in bronchograms The heart is sometimes displaced towards the hypertranslucent side indicating there is no over inflation of this lung Both the hilar and the mid lung field vessels are small but their course is otherwise normal and the peripheral vessels are very inconspicuous Angiography will confirm this generalized vessel narrowing on the affected side but usually throws no light on the cause of the condition

Occasionally a localized irregularity or narrowing of the main pulmonary artery on the affected side is seen in an angiogram which would suggest a primary vascular cause in that case Other cases have been seen to follow prolonged bronchostenosis from enlarged tuberculous glands in childhood These eventually resolved and the bronchus became normal but the hypertranslucency and small size of the vessel shadows persisted Most cases are idiopathic in that no past cause can be demonstrated by th

time they are first observed in a radiograph The disability is slight the other lung being quite normal and the condition is not obviously progressive so that the term unilateral emphysema is perhaps not very satisfactory

The presence of vessel shadows even if they are small will serve to differentiate the condition from a giant air containing cyst or a large pneumothorax In general chronic emphysema the changes may be more marked on one side than the other but the bilateral nature of the changes will suffice for the differentiation

Compensatory emphysema

A common cause of unilateral hypertranslucency is compensatory emphysema which is the condition of over inflation which occurs when lung tissue occupies more space than it would do normally This occurs when a lobe expands to fill the space previously filled by another lobe which has been removed or has become atelectatic following bronchostenosis or infection (Fig 88) The vessels are more widely spaced than normal They may appear relatively narrow if the second generation of branches is mistaken for the first but there is probably no absolute narrowing as in general emphysema In some cases the presence of pleural thickening may counteract the hypertranslucency to some extent but the vessel changes are always apparent The heart and trachea tend to deviate towards the hypertranslucent side

If the shrunken lobe or lobes are clearly visible the diagnosis is obvious and attention is concentrated on the shrunken lobe and not on the hypertranslucent area Sometimes the shrunken lobe is very inconspicuous and a provisional diagnosis of idiopathic unilateral emphysema might easily be made If a shrunken lobe is sought it can always be found with careful radiography if necessary including tomography or even bronchography and then the correct diagnosis will be made

Localized Hypertranslucency

A localized hypertranslucency occupying a limited area of one lung field may be seen in any of the above mentioned conditions causing total unilateral hypertranslucency

For instance a ball valve defect of a lobar or more peripheral bronchus may cause over inflation of the part of the lung supplied by it and hence a local hypertranslucency In theory a small rather peripheral bronchial carcinoma might be the cause of the ball valve stenosis and the local hypertranslucency from the over inflation distal to it would then be the earliest x ray evidence of its presence In a man over 45 years of age such a localized hypertranslucency is much more likely to be due to a bullous area resulting from an uneven distribution of the changes in general emphysema than to a neoplasm

A localized idiopathic hypertranslucency may be caused by a bullous area and may be associated with a normal appearance in the rest of the lungs The cause may be indeterminate even when the specimen is available for detailed examination Nor can the cause of a giant air-containing cyst or bulla always be diagnosed from the radiographs or on histological examination

Compensatory emphysema is usually most marked in the neighbourhood of the shrunken lobe and this may result in a faint localized hypertranslucency especially near a much shrunken middle lobe

A small localized area of hypertranslucency due to focal compensatory emphysema a bullous area or a bulla may be seen near a fibrosing lesion such as a healing tuberculous focus or near the fibrosing lesions sometimes seen in the late stages of sarcoidosis or in some forms of pneumoconiosis Such an area may also be seen in some forms of severe bronchiectasis between the tubular or clubbed finger shadows It is sometimes surprising to see these air-containing bullous spaces in regions where all the smaller bronchi are occluded both in the bronchograms and in the resected specimen

A large pulmonary cavity will result in a hypertranslucent area if there is no fluid in it but its nature is usually made obvious by the thickness of its wall and the character of the surrounding abnormal shadows

5361

CHAPTER 5

CARDIO-VASCULAR ABNORMALITIES

THE CARDIAC SHADOW

FROM a standard anterior view radiograph it is possible to measure the transverse diameter of the heart with greater accuracy than by palpation or percussion The shape and position of the cardiac shadow and the main vessels can also be observed

THE SIZE OF THE HEART SHADOW

The size of the heart is gauged by measuring its transverse diameter (T D) on a radiograph or during fluoroscopy Not only is there considerable variation between different normal people but the size may be artificially exaggerated even in the same person by such factors as his position when the radiograph was taken the phase of respiration or the heart rate (*see* p 12) Pathological enlargement of the T D can therefore be detected in the initial radiograph only if there are no adverse factors and if it is fairly gross Sometimes it is detected first in the radiograph but often the clinician is well aware of some cardio vascular or general disease and the radiograph is taken for the purpose of measuring the T D

The figure obtained from the initial radiograph can be compared with the average figure for a normal person of the same height weight and age from Tables such as those compiled by Hodges and Eyster (1926) or it can be expressed as a ratio by dividing it by the transverse diameter of the thorax and multiplying by 100 Neither method is completely satisfactory for detecting slight degrees of enlargement the Tables because they are based on average figures and do not allow for the range of variation for a given height and weight the cardiothoracic ratio because it shows marked variations from one normal person to another The ratio should not exceed 50 per cent in a normal person but it may reach 55 per cent if the person is obese and has a high diaphragm Similarly a heart which was initially of the narrow vertical type can enlarge considerably as a result of disease before the ratio will reach 50 per cent

Although measurement of the T D from the initial radiograph does not often show with certainty whether pathological enlargement is present or not this measurement is nevertheless a useful base line from which even slight variations may be detected in future radiographs Enlargement can be detected in this way at an earlier stage than by any other method Therefore in some conditions such as valvular disease or some cases of hypertension in which early detection of heart enlargement might be important in the future the initial radiograph for measuring the T D should be taken as soon as convenient after the diagnosis has been made

Enlargement of the T D may be found with a heart of normal shape but it is more often associated with a general alteration of shape as in a large pericardial effusion or in severe myocarditis or with a local prominence of one border such as may be caused by dilatation of one chamber or a local lesion of the muscle or the pericardium

Marked hypertrophy of the muscle round a chamber will not cause an appreciable local enlargement of the heart shadow whereas enlargement is always seen when there is dilatation of a chamber with an increase in the amount of blood contained in it

In assessing either the size or shape of the heart it is of course important to make sure that the lower part of the central shadow is in fact caused by the heart and that the whole or one border of the heart is not obscured by an abnormal mediastinal pleural or pulmonary shadow

Pericardial effusion and myocardial failure

In a large pericardial effusion there is enlargement of the T D and the central shadow assumes a rounded contour The angle between the superior vena cava and the right atrium is filled out givin

an even convex curve to the right border and the angle between the aorta and the left ventricle is filled out giving a similar convex curve to the left border The cardio phrenic angles usually remain acute and there is diminished or absent movement of the heart margins on fluoroscopy or kymography

If the clinical diagnosis is certain the radiological findings can only be of value for confirmation whilst if the diagnosis is in doubt the radiological findings will often fail to narrow down the differential diagnosis The difficulties of diagnosis in pericardial effusion and myocardial failure may be considerable and are discussed in an Annotation (1955) Similar appearances to those of a large pericardial effusion may be seen with dilatation of the heart arising from myocardial failure from almost any cause In acute rheumatic fever especially it may be difficult to tell whether the enlargement is due to a pericardial effusion or to acute rheumatic myocarditis

A similar abnormal shape of the heart may be seen with certain uncommon congenital heart lesions such as transposition of the great vessels idiopathic cardiomegaly or Ebstein s disease

The sudden enlargement of the heart shadow in serial radiographs will also suggest a pericardial effusion especially if there is no clinical evidence of myocardial disease or if earlier radiographs indicate a possible cause for the effusion such as the shadow of a tuberculous lesion or neoplasm in the lung or a pleural effusion

A small pericardial effusion may cause no alteration in the heart contour nor obvious restriction of movement on kymography A moderate effusion will cause rather less alteration in size and shape than a large effusion but distinction from moderate heart enlargement from myocarditis will still be difficult

Pericardial constriction

Pericardial constriction may follow a tuberculous pericardial effusion after an interval of several months or it may supervene while the effusion is still present more often it arises however without a previous history of pericardial disease In the latter case the heart shadow is often small and rounded and the angle between the superior vena cava and the right atrium is lost or even filled out so that the right border forms one continuous convex curve from the top to the diaphragm Diminution or complete absence of movement may be seen on fluoroscopy and recorded by kymography The constriction may be generalized or may be confined to one border so that in a case of doubt an oblique view kymogram should also be taken

Pericardial deficiency

A developmental deficiency in one part of the pericardial sac will result in a local prominence of the heart through the gap in the covering This may occur over the upper part of the left border the resulting prominence being due to the pulmonary artery or left atrial appendage and simulating a patent ductus or atrial septal defect

Pericardial adhesions

A pericardial adhesion to the pleura may be visible on the radiograph as a localized peaking out of one heart border towards a lung field although this may be visible in the plain radiographs or on fluoroscopy a kymogram may be useful to confirm the diagnosis This may show a localized alteration of the movements of the heart border in the region of the adhesion and the local protuberance of one border will become more conspicuous during systole than diastole since it will be held out towards the part to which it is adherent when the rest of the heart contracts medially The adhesion may draw towards the heart during systole some nearby part which is visible radiologically such as some thickened pleura or the chest wall in the lower axillary region Such systolic indrawing may be shown in the kymogram even when it is not clinically very obvious

Localized High or Low Density Shadows

Pericardial calcification

Pericardial calcification may occur without constriction It may pass undetected in a routine anterior view but be clearly seen in a more exposed radiograph and is often most clearly seen in a lateral view (Fig 125) or left anterior oblique view It may stand out most clearly when the radiograph is taken with a Potter Bucky diaphragm

The shadow is often a 2–5 millimetre line or band which curves in an almost circular or semicircular manner round the heart usually lying 1–2 millimetres deep to the actual border and often thickest and most conspicuous along the lower border just above the diaphragm Sometimes a shorter and wider band like shadow is seen and if it is of limited extent and lying posteriorly its position near the edge of the heart may only be appreciated in a tangential view

Sub endocardial calcification

A pericardial calcification must be distinguished from a dense circular line shadow which is sometimes seen when there is sub endocardial calcification in the wall round an enlarged left atrium in mitral stenosis or round the edges of an intra atrial thrombus The clinical picture and the position of the shadow lying as it does high up posteriorly will generally serve to differentiate the two conditions

Valvular calcification

A local increase in the radio opacity of the heart shadow may also be seen if extensive valvular calcification is present an appearance which is quite common in severe mitral or aortic stenosis This shadow is generally rather mottled and is rarely more than 1–2 centimetres long and 2–5 millimetres wide It may be band like elliptical or in the form of a ring The shadow is often invisible in a routine radiograph of the chest but may be visible in one which was well exposed and for which the time of exposure was very short and less than 0 05 seconds It is best demonstrated if the radiograph is taken at a relatively high kilo voltage which with many units will mean 80–90 kVP but it will stand out even more clearly if taken at about 120 kVP using a clearing grid It can often be clearly demonstrated by tomography and can often be seen during fluoroscopy provided the eyes of the observer are particularly well adapted to the dark On fluoroscopy the shadow shows a characteristic rotatory movement in phase with the heart beats which serves to differentiate it from the shadows of calcified hilar glands No doubt screen image amplification will make the detection of valvular calcifications easier but for the present such units are not available at many centres

In an anterior view the shadow should be sought on the left side If the point of change of movement on the left border is noted and one line drawn horizontally from this a second vertically downwards and a third at 45 degrees between the two then a calcification in the aortic valve will tend to lie just above this last line and one in the mitral valve just below it (Wood 1950) When the calcification is abundant the shadow is usually quite conspicuous but if it is slight it is often of little clinical importance so that a very careful radiological search for such shadows is rarely called for

Pneumopericardium

A pneumopericardium may result from trauma aspiration or from rupture of an air containing space adjacent to it such as a pneumothorax or pneumomediastinum

If the amount of air is small the resulting translucent zone round the borders of the heart will be only 1–2 millimetres wide and may be very inconspicuous but can often be detected if the possibility of this condition is borne in mind If the amount of air is larger the translucent zone may be as much as 2 centimetres wide and may be made even more obvious by the presence of a fluid level The translucent zone is sharply demarcated by the 1 millimetre line shadow of the parietal pericardium which runs parallel to the heart shadow with a lateral convex curve and which is superimposed on either lung field If as a result of inflammatory changes or the deposit of fibrin from a haemopneumopericardium the pericardium is much thickened then the translucent zone will be demarcated by a band like shadow several millimetres wide

LOCALIZED PROMINENCE OF ONE HEART BORDER

Encysted pericardial effusion hydatid cyst or tumour of the heart muscle

A localized convex prominence of one heart border with a well defined margin about 2–3 centimetres long and 1–2 centimetres deep may be seen if some pericardial fluid is encysted Radiologically a similar appearance may be seen with fluid encysted in the mediastinal pleura adjacent to the heart or with a tumour of the heart muscle or a hydatid cyst in the wall of the heart

Such a protuberance of the right heart border is often clinically silent and first discovered on a routine radiograph It may be necessary in some cases to show the relationship of the right atrium to the shadow If a cardiac catheter is introduced into the atrium and its tip directed laterally towards the shadow it will be possible to estimate the width of the shadow beyond this chamber and thus see if the shadow is formed by a protuberance of the right atrium or whether it is independent of or even encroaching on it This method will cause less discomfort to the patient and be less dangerous than angiocardiography

Cardiac aneurysm

A localized protuberance of the left border in the region of the left ventricle is seen in many cases of cardiac aneurysm following a myocardial infarction The protuberance is commonly situated where the more horizontal part of the left border turns downwards and it tends to protrude upwards as well as laterally so that the lower half of the left border has the shape of the toe of a well worn shoe In a right anterior oblique view the upper margin of the bulge runs almost horizontally and then curves downwards to meet the sternal shadow thus producing a step like appearance of the anterior part of the heart shadow The clinical picture is generally characteristic and the electrocardiograph is diagnostic so that the radiograph is chiefly of value to show the size of the protuberance and the T D rather than for diagnosis

Dilatation of the left ventricle

Dilatation of the left ventricle is common in hypertension aortic stenosis aortic regurgitation or mitral incompetence In the anterior view it causes a prominence of the lower third of the left border and therefore an increase in the T D The shape of the lower third of the left border tends to remain rounded

In a right anterior oblique view little change can be seen but in the left anterior oblique view there is some enlargement posteriorly of the lower third of the posterior border The extreme posterior part of this border will overlap the shadow of the vertebral column until the patient is rotated nearly into the true lateral position

Dilatation of the right ventricle

Dilatation of the right ventricle may give a very similar appearance on the radiograph if it displaces the left ventricle to the left and posteriorly More commonly the appearances are more specific the dilated right ventricle causing a prominence of the left border rather above the apex of the heart whilst in the left anterior oblique view it projects anteriorly and tends to overlap the sternal shadow while the retrocardiac space is not encroached upon

In some congenital heart lesions gross dilatation of the right ventricle producing a prominence of the left heart border above the apex is associated with a small hypoplastic pulmonary artery producing a deep concavity below the aortic knuckle The combination of these changes results in the left border of the heart simulating the shape of a well worn boot or *coeur en sabot* This appearance is sometimes seen in Fallot s tetralogy but is in fact more often caused by some variant of this the changes in the size and shape of the heart shadow resulting from Fallot s tetralogy usually being much less marked In this condition the T D is often normal or only slightly increased even if the pulmonary ischaemia is obvious

A dilated right ventricle often displaces the right atrium to the right but this may not be a very conspicuous feature nor is the dilatation of the right atrium which usually accompanies that of the right ventricle easy to detect on the plain radiographs or on fluoroscopy An impression of prominence of the right border of the heart is often obtained in these cases The lower part of the right border of the heart is rather more convex and this convexity extends higher than normal before meeting the straight vertical part of the central shadow formed by the superior vena cava The actual enlargement is however difficult to measure

In most cases the clinical picture and particularly the electrocardiograms will indicate which ventricle is enlarged In a doubtful case the radiographic findings must be interpreted with caution because as indicated above dilatation of the right ventricle may give the same picture as that seen with dilatation

of the left ventricle If however the more characteristic appearances of dilatation of the right ventricle are present these are not simulated by dilatation of the left ventricle

Dilatation of the left atrium

When there is moderate dilatation of the left atrium in mitral stenosis a prominence of the left border is often seen a short distance below the aortic knuckle Since the left atrium lies behind and well inside the left border this prominence is formed by the left atrial appendage The position of the left atrium and atrial appendage and their relation to the left border can be confirmed by angiocardiography though filling of the appendage may be very faint and difficult to detect

A prominence of the left border rather higher up immediately below a small hypoplastic aorta is generally caused by the associated dilatation of the pulmonary artery Sometimes both prominences are seen the upper one due to the large pulmonary artery the other immediately below it to the left atrial appendage which may itself be enlarged or may be quite small but displaced to the left by the enlarged left atrium itself

A dilated left atrium causes a slight increase in the radio opacity of the heart shadow which is most clearly seen in a well exposed film The right border of this denser area results in a double outline the outer border being the right border of the heart formed by the right atrium the inner border 1-2 centimetres medial to it and roughly parallel to it being formed by the dilated left atrium If the left atrium enlarges still farther it will itself form the lower half of the right border of the heart shadow while the right atrium will appear as a second denser area medial to it If marked mitral incompetence is present rather than stenosis the dilatation may be very gross so that the shadow of the greatly enlarged left atrium passing posteriorly reaches as far as the right axilla

If the dilatation of the left atrium is slight it may not be revealed in the routine anterior view *radiograph in which both the T D and the heart shape may appear normal* but whether slight or considerable it can be readily detected in a right anterior oblique view (45 degree rotation) when it will be seen to cause some posterior deviation of the oesophagus after it is outlined with barium sulphate paste The displacement starts just below the lower end of the tracheal translucency and ends unless it is gross a short distance above the diaphragm Rarely such slight dilatation can be detected before the characteristic murmur of mitral stenosis can be clearly heard but generally the physical signs precede the radiological evidence of dilatation of the left atrium and the clinical picture is such that the radiological examination is not necessary for diagnosis It will however show the degree of enlargement of the left atrium and state of the pulmonary vessels and lungs

The oesophagus is usually displaced to the right as well as posteriorly but it is sometimes deviated to the left by the enlarged chamber

A grossly enlarged left atrium will often press on the main bronchi and displace them laterally thus widening the carinal angle This may be seen in a well exposed anterior view or left anterior oblique view radiograph or it can be demonstrated by tomography which may sometimes show narrowing of the left main bronchus as well

In mitral valvular disease with dilatation of the left atrium it is sometimes important to determine whether mitral incompetence rather than stenosis is the predominant feature This will be suggested if on fluoroscopy or kymoscopy marked systolic expansion of the left atrium can be seen particularly in the right anterior oblique view Owing to the overall movement of the heart shadow systolic expansion is largely an impression the observer gains but it may be demonstrated by kymoscopy If it is slight it generally cannot be detected with certainty On the other hand if the incompetence is gross so that the systolic expansion can be seen more easily the condition will be obvious clinically and its radiological demonstration therefore of no great importance

Dilatation of the right atrium

Dilatation of the right atrium is difficult to detect on the plain radiographs It will result in some prominence of the right heart border but the recognition of this will depend largely on the impression gained by the observer The lower half of the right border tends to be more convex and to extend higher before meeting the superior vena cava than in a normal heart The prominence may be measured with more reassurance by dropping a perpendicular line down from the lateral edge of the shadow of the superior vena cava and noting the distance of the right border from this

Dilatation of the right atrium is often seen in pulmonary hypertension associated with dilatation of the right ventricle in an atrial septal defect and in tricuspid stenosis

Dilatation of several chambers

Often there is dilatation of more than one chamber For instance an increase of the T D with prominence of the apex and of the left border below the aortic knuckle may be seen in the anterior view together with some enlargement posteriorly in the right oblique view from dilatation of the left atrium In the left anterior oblique view there may also be enlargement posteriorly from dilatation of the left ventricle a combination seen when mitral stenosis is associated with aortic regurgitation



Fig 125—Calcified pericardium The shadow was invisible in the routine anterior view radiograph It could be seen in a more exposed anterior view and was most conspicuous in the lateral view The white band like shadow of the calcium forms most of the margin of the heart



Fig 126—Congenital double aortic arch (aortic ring) Note indention on posterior wall of barium filled oesophagus from abnormally placed vessel Child aged 1 year Recurrent respiratory infections with stridor Left aortic arch compressed trachea and was tied off Good recovery

The Place of Radiology in Cardiac Disease

In many cases of cardiac disease the diagnosis is obvious from the clinical and electrocardiographic findings but in a few cases the radiological findings may have an important place even in the diagnosis They are of particular value in estimating some of the adverse effects arising from a valvular or other lesion and such information may help in deciding on the line of treatment

Sometimes it is necessary to obtain further information by cardiac catheterization and there are of course many conditions in which it is indicated either for diagnosis or for assessment of the case For instance it may serve to distinguish a patent ductus an atrial septal defect and a ventricular septal defect in all of which there may be an increase in the T D a prominence of the pulmonary artery shadow and pulmonary plethora and which in their less usual manifestations cannot be distinguished on clinical investigation

Sometimes angiocardiography is an invaluable aid to diagnosis in an obscure congenital heart lesion or it may be useful in showing certain features which will assist the surgeon in planning the operative procedures For instance in Fallot s tetralogy it will show the size of the subclavian artery and

pulmonary arteries and the degree of over riding of the aorta In a coarctation of the aorta it will show the site and extent of the narrowing the width of the aorta above and below it and the relation of the subclavian or other large artery to it

The indications for angiocardiography and the x ray appearances seen by this method are within the province of cardiology and have therefore been omitted In chest disease as opposed to cardiology it may be indicated to show whether an abnormal mediastinal shadow is associated with a normal appearance of the heart chambers and great vessels or whether some abnormality is present such as an aneurysm which is the cause of the mediastinal shadow

THE AORTIC SHADOW

Prominence of the central shadow particularly the upper half may be due to unfolding of the aorta or dilatation due to aortic regurgitation aortitis or an aneurysm The enlargement may be associated with an increase of the transverse diameter of the heart especially if there is a lesion of the aortic valve but sometimes there is gross enlargement of the central shadow from an aortic aneurysm and no enlargement of the heart shadow

Unfolding of the Aorta

Unfolding of the aorta without actual dilatation is a condition which is often seen in older persons particularly men over 65 years of age In the anterior view it causes a lateral convex prominence of the middle third of the central shadow on the right side and a prominence of the aortic knuckle on the left side both having well defined margins On the right side the upper part of the prominence may be caused by the displaced superior vena cava On the left the aortic knuckle not only projects out farther but is higher than in a normal younger person The descending aorta may curve considerably to the left and the shadow formed by it may be so marked as to simulate a mediastinal tumour projecting out from the region between the aortic knuckle and the left ventricle A well exposed anterior view radiograph will show the continuity of this aortic shadow from the knuckle to the diaphragm while an oblique or lateral view will confirm the absence of any abnormal mediastinal shadow The oblique and lateral views will also show that there is no appreciable increase in width of the aortic shadow the walls of which remain parallel A considerable kyphosis is often apparent

Syphilitic Aortitis

In syphilitic aortitis the increase in size of the central shadow is less obvious than in unfolding of the aorta but in an oblique view preferably the left anterior oblique view a local or general increase in width of the aorta will be apparent Faint lines of calcification are sometimes seen which are much thinner than those seen in atheroma

Aortic Aneurysm

In a routine anterior view radiograph an aortic aneurysm will often result in a large homogeneous shadow projecting out from the central shadow If it arises from the ascending aorta the prominence will be seen on the right side of the central shadow at the level of or somewhat above the hilum *Rarely it extends downwards when the appearances will be exactly the same as that of the mediastinal* effusion illustrated in Figs 35 and 36 p 31

If it arises from the descending aorta it may project to the left behind the hilum shadow If the aneurysmal dilatation is S shaped it may project behind the right hilum or lower down on the right border of the central shadow The posterior position of the shadow will be evident from oblique or lateral views and the correct diagnosis thus made If the aneurysm is fusiform and low down just above the diaphragm the shadow will simulate that of a collapsed lower lobe *There will however* be none of the other changes such as alteration of the lung vessel pattern and hypertranslucency

Sometimes the routine anterior view appears normal whereas the aneurysm is either seen clearly in one of the oblique views in a high penetration anterior view in a kymogram or is inferred from oesophageal displacement demonstrated after a barium swallow Therefore when an aneurysm is suspected clinically these further radiological investigations should be carried out whether the anterior view appears normal or whether it shows a shadow of doubtful nature

The condition will be excluded if the shadow of the aorta is seen to be independent of and sufficiently remote from the abnormal shadow The shadow of an aortic aneurysm would be in contact with that of the aorta at some point and would usually be obviously continuous with it both at the proximal and distal ends

Considerable displacement of the oesophagus round the shadow is common if the aneurysm is in the region beyond the ascending part The displacement is usually more marked than with a neoplasm

Erosion of the sternum is common with an aneurysm of the ascending aorta and erosion of one or two vertebrae with an aneurysm of the descending part These vertebral erosions tend to be in the anterior part of the vertebral body and result in a deep anterior concavity since the intervertebral structures are relatively resistant to the pressure erosion (Fig 132) Generally there is no reactive sclerosis Often both sternal and vertebral erosion is most easily seen in a true lateral view Sometimes the vertebral erosion is at the side of the vertebral body and can then only be seen in a posterior view taken for the bone

Sometimes an aneurysm presses on a bronchus and its shadow may then be obscured by that of the collapsed lung Often only a single lobe collapses or distal inflammatory changes result in an area of patchy clouding the shadow of the aneurysm remaining visible near the hilum

Sometimes the clinical and radiological findings indicate the diagnosis quite clearly at others there may be no clinical clues while radiologically it may be difficult or impossible to distinguish the shadow from that of a mediastinal neoplasm (*see* p 117)

Congenital Anomalies of the Aortic Arch

In babies or young children stridor may be caused by a persistent aortic ring pressing on and narrowing the trachea The plain radiographs may appear normal but a small barium or Lipiodol swallow will show a small indentation of the posterior wall of the oesophagus with some forward displacement at about the level of the third and fourth thoracic vertebrae The appearances are most easily seen in a right anterior oblique view (Fig 126) Sometimes the oesophagus shows a slight narrowing on both sides in the anterior view that on the left corresponding to the normal aortic indentation and that on the right corresponding to the aortic ring The tracheal narrowing may be seen in tomograms but it is not always possible to obtain a clear picture in a restless baby

Anomalous Venous Drainage

In a baby or child an anomalous venous drainage into the heart may result in a very wide upper mediastinal shadow This is seen with total pulmonary venous drainage through a persistent left superior vena cava The edges are often rather poorly defined though formed on the right by the superior vena cava and on the left by the anomalous vein and they may simulate a mediastinal tumour The nature of the shadow may be demonstrated by cardiac catheterization if the catheter can be made to enter the abnormal vein or it may be shown by angiocardiography

THE PULMONARY VESSELS IN CARDIAC DISEASE

Considerable changes may be present in the pulmonary circulation as a result of cardiac disease and some of these may be reflected in the radiographic appearances The pulmonary vessel pattern should therefore be inspected as a whole starting with the heart contour particularly that part of the left border below the aortic knuckle which is formed by the part of the pulmonary artery between the valve and its division into a right and left branch and then proceeding from the hilar vessels outwards into the larger intrapulmonary vessels to end with the smaller peripheral vessels The larger pulmonary veins may also be separately identified

Dilatation of the Pulmonary Artery

Dilatation of the pulmonary artery producing a prominence of the left cardio vascular border below the aortic knuckle is a common finding in many cardiac conditions It is seen associated with a high pulmonary artery pressure or an increased pulmonary blood flow in such conditions as mitral stenosis atrial septal defect (A S D) ventricular septal defect (V S D) patent ductus and with a low pressure

in the post-stenotic dilatation of pulmonary stenosis. The shadow may also be caused by a local aneurysmal dilatation of the pulmonary artery associated with a normal pressure, the dilatation being either a developmental anomaly or the result of an abnormally thin and distensible arterial wall.

In many cases of mitral stenosis, A.S.D., V.S.D. and patent ductus, the large pulmonary artery tends to be associated with large hilar vessels and pulmonary plethora, whilst in some cases of mitral stenosis with extreme pulmonary hypertension considerable enlargement of the pulmonary artery is associated with abnormally small hilar and lung vessels (Fig. 128), a similar pulmonary ischaemia being seen beyond the post-stenotic dilatation of pulmonary stenosis.



Fig. 127.—Mitral stenosis with large indistinct hilar shadows. The mid-lung field vessels are inconspicuous. Some very small circular lung shadows in the mid-zones due to haemosiderosis. Male aged 34 years. Ten years progressive dyspnoea on moderate exertion, fibrillating. Successful valvotomy.



Fig. 128.—Mitral stenosis with large pulmonary artery but small lung vessels. Horizontal line shadows above the costo-phrenic recesses. Female aged ?3 years. Many years breathless on exertion, becoming more severe. P.A. pressure 100/45. Valvotomy. Very great improvement.

Dilatation of Vessels in the Region of the Hila

Dilatation of the vessels in the region of the hila is commonly seen in association with the main pulmonary artery in mitral stenosis, A.S.D., V.S.D. and patent ductus. The enlargement may continue into the lung fields or end abruptly after the early branchings, beyond which the vessels may not be enlarged at all or may even be narrowed. In A.S.D. in particular there is a tendency for enormous enlargement to take place of some of the more proximal branches, which contrasts oddly with the quite normal size of the vessels of the next generation within the lungs. The enlargement of the early branches is often uneven, so that great enlargement of only one or two may suggest a tumour or enlarged hilar glands. In some lesions causing enlargement of the hilar vessels excessive pulsation may be seen on fluoroscopy, an appearance described as hilar dance. This can be recorded graphically by kymography or kymoscopy.

Slight or only moderate degrees of enlargement of the vessels in the region of the hila is difficult to detect, being based on a visual impression and not on any measurements. The vessels are frequently reported as being enlarged in mitral stenosis or cardiac failure when in fact enlargement is not a marked feature. Often in mitral stenosis the vessel outlines are rather indistinct and yet the hilar shadows appear large and ill-defined, an appearance which is probably the result of a localized mediastinal oedema around the vessels without measurable enlargement of the individual vessels (Fig. 127).

Dilatation and Narrowing of Larger Intrapulmonary Vessels

Assessment of the dilatation of the larger intrapulmonary vessels is similarly based on a visual impression and not on direct measurement and will therefore where the lesser manifestations are concerned depend a lot on the attitude of the observer Enlargement of the smaller branches makes them more clearly visible and vessels which normally would not be noticed are now clearly seen so that there seems to be an excessive number of vessels This appearance of vascular congestion is known as pulmonary plethora Diminution of the size and therefore of the number of visible vessels in the lung fields is known as pulmonary ischaemia and is seen with some cases of extreme pulmonary hypertension and in certain congenital cardiac conditions such as pulmonary stenosis Fallot s tetralogy or Eisenmenger s syndrome

Dilatation of the Small Peripheral Vessels

The peripheral smaller vessels are normally invisible or inconspicuous and only become clearly visible when they are enlarged as for instance in some cases of mitral stenosis Enlargement of the peripheral vessels may be distinguished from dilated lymphatic channels if the linear shadow can be traced back to arborizing shadows leading directly to the main hilar vessels Excessive visibility of engorged peripheral vessels may give rise to an almost reticular pattern in the lung This is different from the non vascular reticulation seen in some forms of idiopathic pulmonary fibrosis in which the criss cross white lines have a finer more even contour than in vessel engorgement

TABLE 1

Changes in the Vessel Pattern associated with some of the more common Cardiac Lesions

Mitral stenosis	Vessel pattern variable Commonly slight or moderate dilatation of the pulmonary artery Hila blurred Lung and peripheral vessel conspicuous with pulmonary congestion obvious (Fig 1 7) If pulmonary hypertension extreme pulmonary artery large but lung vessels small and no congestion (Fig 178)
Patent ductus A S D V S D	The range is wide from normal to gross plethora Tendency to dilatation of the pulmonary artery
Pulmonary stenosis	Dilatation of the pulmonary artery with pulmonary ischaemia
Fallot s tetralogy	Sometimes normal sometimes all vessels small
Truncus arteriosus	All vessels small Wide upper mediastinal shadow and step appearance in left oblique view

LUNG CHANGES IN CARDIAC DISEASE

Cardiac disease may not only cause alterations in the pulmonary vessel pattern but may result in abnormal shadows in the lungs themselves

Haemosiderosis

Haemosiderosis is a condition in which iron particles from the blood stream are deposited in the pulmonary tissues It occurs in a small proportion of patients with mitral stenosis Quite often the small particles are in a sufficiently large group to cast a 0 8–1 millimetre circular shadow on the radiograph They can generally be identified because similar shadows of this small size made up of particles of a lower molecular weight would not ordinarily be visible They are for the most part widely disseminated over the middle thirds of both lungs and may be sparse or so numerous that they result in a ground glass appearance and the radiograph may appear under exposed

If the shadows are only moderately numerous and of larger size reaching up to 2 millimetres in diameter distinction from fibrotic nodules without haemosiderin deposits associated with them may be impossible In addition the shadows may be further obscured by the presence of shadows from engorged peripheral vessels or even oedematous areas in the lung Histologically the size of the iron stained particle may sometimes correspond to that of the shadow visible on the radiograph though it is probable that the shadow is often formed by the superimposition of several deposits at quite different levels in the lung and is thus larger than the actual individual particle

Pulmonary Fibrosis

Pulmonary fibrosis may occur in severe long standing mitral stenosis It is as a rule associated with engorgement of the pulmonary vessels and the effect of these superimposed on the shadows of the fibrous tissue is to give a complicated series of shadows which has a reticular or net like or even a honeycomb appearance

Ectopic Bone

Ectopic bone in the form of several 2–3 millimetre well defined circular shadows lying in the lower half of the lungs is occasionally seen in a patient with mitral stenosis (Fig 108) These lesions are probably the result of old foci of rheumatic pneumonia occurring at the time of the original rheumatic fever and not of the cardiac lesion



Fig 129 —Pulmonary oedema with bat s wing shadow A male aged 27 years with hypertension and left ventricular failure Blood pressure Albuminuria Blood urea 50–380 milligrams per cent Retinopathy



Fig 130 —Pulmonary oedema with basal haze A case of mitral stenosis Female aged 48 years Short of breath and swelling of the ankles Cyanosis and orthopnoea fibrillating Improved on digitalis and low salt diet

Pleural Effusion

A small pleural effusion or line of thickened pleura is a common complication when heart failure occurs Thickening of the horizontal fissure may persist long after the patient has recovered from a temporary failure A small effusion can be more readily demonstrated on the radiographs than clinically (see p 25)

Pulmonary Oedema

Pulmonary oedema in heart failure is often masked by an associated effusion but the lung shadow may be the predominant feature and appear as a generalized lower zone haze with a poorly demarcated upper edge (Fig 130) The shadow is on the whole less dense than a pneumonic consolidation and tends to remain more homogeneous over a longer period of time This appearance may be seen on one or both sides

A more common form of pulmonary oedema results in the bats wing shadow (Fig 129) which is partly homogeneous and partly composed of 1 centimetre ill defined confluent woolly shadows It spreads out from the hila and stops short often with quite a well defined edge some 2 centimetres from the periphery of the lung It is seen in some cases of left ventricular failure from whatever cause

It is commonly found in hypertension with uraemia but may also occur in hypertension without uraemia in ischaemic heart disease or even in myocarditis or mitral stenosis it may occur with some biochemical disaster but without a long standing or irreversible cardiac lesion

THE PULMONARY VESSELS IN HEALTH AND IN LUNG DISEASE

Variation in Arborizing Vessel Shadows in Normal Persons

The arborizing shadows in the lungs of a normal person (the lung markings) are without doubt due to the pulmonary arteries and veins This can be demonstrated by tomography in a region near the hilum where the bronchial translucencies the branches from the main division of the pulmonary artery on that side and the venous branches reaching the shadow of the left atrium can be separately identified Further evidence can be obtained by angiocardiography when first the arteries and then the veins are reinforced by the contrast medium

These vessel shadows are much more conspicuous in some subjects than in others mainly because of variations in the contrast between them and the surrounding translucent air spaces and to a less extent because of variations in the size of the vessels Even if they appear especially numerous in a particular patient this impression is not borne out by an actual count either in the radiograph or in casts after the injection of the vessels

On the other hand in the same normal subject the pattern is remarkably constant in radiographs taken at different times over a period of many years and is the same in a radiograph taken immediately after violent exercise as after a period of rest

Changes in Vessel Pattern Associated with Lung Disease

The pulmonary artery

Enlargement of the pulmonary artery producing a slight convex prominence of the left heart border just below the aortic knuckle is a common finding in emphysema or any other form of generalized lung disease causing pulmonary hypertension In emphysema this enlargement although not gross is nearly always present and easy to detect Unless heart failure is present it is usually associated with a rather small narrow vertical heart The hilar vessels may be enlarged or may merely appear enlarged because of the high contrast with the exaggerated overlying lung translucencies—in marked contrast to the more *proximal intrapulmonary vessels which are smaller than normal If bullae or bullous areas are* present the vessels will be abnormally widely spaced and even reduced in number The peripheral vessels just above the costo phrenic recess may stand out abnormally clearly In cor pulmonale this picture is punctuated by episodes of failure when the heart shadow may enlarge only to decrease again in size if the patient improves

A slight prominence of the left heart border below the aortic knuckle suggesting some enlargement of the pulmonary artery is quite commonly seen in the radiograph without any clinical evidence of disease and is often normal It may be dynamic and associated with a rapid pulse rate but more commonly it is an artefact due to slight rotation or scoliosis the prominence disappearing if the patient can be positioned correctly

Main branches of the pulmonary artery

One or both branches of the pulmonary artery may be enlarged Unilateral enlargement is usually only an apparent and not a real enlargement and is seen frequently when the patient is not positioned straight The left branch will be prominent if the sternal end of the left clavicle is seen to be more to the left of the vertebrae than the right or if there is a thoracic scoliosis convex to the left The reverse will cause prominence of the right branch of the pulmonary artery situated in the hilum Such an apparent enlargement is frequently mistaken for a pathological shadow in the region of one or other hilum and it may require quite elaborate radiological investigation to show the shadow is in fact the normal arterial shadow A view with the patient straight if this is possible and the appropriate lateral view should be taken first If there is still doubt then posterior or lateral view tomograms or both may be necessary In such cases the speed and ease of the simultaneous multisection method (*see* p 172) is a great help for a nervous patient

The intrapulmonary vessels

The visible vessels in the hila and lungs are the vessels associated with oxygenation as opposed to the much smaller bronchial vessels nourishing the bronchial walls They are not visibly increased in size even after vigorous exercise Neither they nor the walls of the proximal bronchi become sufficiently thickened to show a change in size in acute or chronic bronchitis Any impression of vessel enlargement gained from the radiograph of a person who is without evidence of cardiac disease but who is suffering from a cough does not therefore justify a diagnosis of a pathological lung change Serial radiographs often show no change even when the subject is well which is an additional reason for considering this unusual vessel pattern to be normal and a diagnosis of a catarrhal condition or hilar flare to be unjustified

In the lesion of interstitial pneumonia the tissues round the vessels and bronchi are inflamed The resulting picture may simulate that of vessel enlargement although the changes are not strictly confined to the vessel pattern

In some patients with asthma the vessels stand out abnormally and are rather small the pattern being similar to that seen in emphysema (For the changes in the lung vessels in asthma or chronic bronchitis with emphysema *see* p 98)

The small peripheral vessels

The small peripheral vessels are normally inconspicuous or invisible but may be seen in very thin subjects They stand out very clearly in some cases of emphysema and some manifestations of pneumoconiosis They must be distinguished from dilated lymphatics and thickened inter lobular septa neither of which can be traced medially to join up with the other arborizing vessel shadows

Local change in lung vessel pattern

A purely local change in the vessel pattern is seen in some lung diseases For instance in localized bullous emphysema there is a local area of vessel narrowing In idiopathic unilateral emphysema *all* the vessels (arteries and veins) on one side are abnormally small

Displacement of a vessel or group of vessels by a localized lung lesion is common They may be spread out around a cyst or neoplasm or be crowded together in a lobar shrinkage

Sometimes a localized pathological shadow may be associated with radiological evidence of an increased blood supply In an arterio venous aneurysm in the lungs the aberrant and enlarged vessels can be clearly shown by tomography (Fig 100) Occasionally an abnormal artery coming from the thoracic or abdominal aorta can be shown leading to a sequestrated segment

In most other localized lesions dilatation of the vessel supplying the lesion is either slight or cannot be demonstrated on the radiograph There is sometimes an appearance of an increased vascular supply leading to the opacity of a tuberculous focus but it is difficult to be sure whether this explanation is the correct one or whether the appearance is due to tubercles and fibrous tissue seeded along the lymphatics which lie around the vessels and bronchus and pass between the focus and the hilar gland to which it drains

PULMONARY INFARCTS

A pulmonary infarct is usually the result of a thrombo embolus from a leg or pelvic vein though it may occur from right sided sub-acute bacterial endocarditis In the early stages it is often not possible to obtain very satisfactory radiographs without unjustified disturbance of the patient and even a lateral view may often be inadvisable The shadow is variable depending on its location and the size of the infarcted zone It is usually ill-defined often 1–3 centimetres in size and in an anterior view appears rather shapeless sometimes it is wedge shaped with the apex towards the hilum especially in a lateral view sometimes it is circular 1–2 centimetres in diameter

A large infarct especially if it occurs in the upper half may result in a shadow corresponding to a lobe or a segment but such a finding is unusual If the infarct occurs in the lower half the shadow is frequently obscured by or merges with that of a complicating effusion or it is partly hidden by a much raised dome of the diaphragm This marked elevation of the diaphragm on the affected side is a common feature and may be present with quite a small lesion

As the infarct resolves the shadow shrinks rapidly and may then persist for 2 or 3 weeks A frequent finding in the healing stage is a long 1–3 millimetre wide linear shadow which in the lower zone often lies horizontally just above the diaphragm This may eventually resolve completely or it may leave a residual small linear scar

An infarct may occur without cardiac disease or thrombo embolus and is not uncommonly seen in cases with bronchial carcinoma The shadow cannot always be separately identified on the radiograph in these cases being merged with the shadow of an atelectasis or distal inflammation beyond the bronchostenosis On the other hand the infarct may sometimes cast a separate wedge shaped or circular shadow remote from the growth In some cases neoplastic invasion of the vessel can be seen on examination of the specimen but in others no cause can be found for the infarct

CHAPTER 6

THE MEDIASTINAL AND DIAPHRAGM SHADOWS

THE BORDERS of the central (mediastinal) shadow which are outlined by the translucent lung fields on either side are normally formed by the heart and its pericardial covering together with the great vessels An abnormality of the size shape or density of this shadow may result from cardiovascular disease as described in Chapter 5 It may also result from enlargement of one of the other contents of the mediastinum which are normally invisible such as the oesophagus thymus lymphatic glands or part of the vertebral column Finally it may be due to the presence of a tumour hernia or effusion

The diaphragm shadow is intimately related to mediastinal lesions lying in the lower part such as a parapericardial or pleural cyst a pleural fibroma or a lipoma resting on it It may itself contribute to *the mediastinal shadow either when a local defect permits a hernia into the mediastinum or when a* portion of one dome of the diaphragm is pushed upwards as a result of a local weakness allowing the shadow of the liver or spleen to encroach on a lung field

CONFIRMATION AND LOCALIZATION OF THE ABNORMAL SHADOW

It will usually be possible to make quite sure that a suspected shadow is in fact an abnormal shadow and not just an unusual normal shadow resulting from a minor variation in the size or position of some normal structure or even an artefact Tomograms are often of great value to confirm the presence of a small and inconspicuous abnormality the lateral view being the most suitable in some cases and the posterior in others

Whether the shadow is small and inconspicuous or large and obvious its spacial position has to be determined A plain lateral view will generally suffice to prove that it does in fact lie in one of the mediastinal spaces or is related to the diaphragm sometimes however more elaborate investigations are needed such as a high penetration anterior view a similar view taken with a Potter Bucky diaphragm tomograms fluoroscopy and a barium swallow

DIAGNOSIS OF THE ABNORMAL SHADOW

There may be clues to the diagnosis from the clinical side such as physical signs suggesting an aneurysm an abnormal blood count indicating leukaemia or a gland biopsy indicating one of the reticuloses In the absence of any such clinical clues not only is differentiation of an aneurysm from a neoplasm or inflammatory mass sometimes difficult but in many cases a pre operative opinion as to the nature of the abnormal shadow can only be a hazardous guess

The size of the shadow its shape and density should be noted since certain features may point to one diagnosis rather than another Examples of this are the size of the shadow in a parathyroid tumour the shape of the shadow seen on the right border in a megaoesophagus or cardiospasm gas *translucencies seen in a hernia or the presence of teeth or small calcifications in a dermoid* Tomograms are sometimes useful to prove or exclude the presence of small inconspicuous calcifications in the tumour

Accurate localization of the shadow will also contribute towards the diagnosis if as is often the case there is no evidence of disease other than the x ray findings Certain lesions are found in one region but not in another or are more common in certain sites

Differential diagnosis of any mediastinal shadow may be a problem and even exact anatomical *localization is not always easy In particular a bronchial carcinoma lying very medially will occupy* the same spacial site as mediastinal secondary deposits and will therefore be indistinguishable from these unless there are other clues such as a bronchostenosis An encysted effusion of the mediastinal pleura will give rise to a shadow indistinguishable from a mediastinal tumour or an aneurysm

Differentiation of Aneurysm from Tumour

If there is any possibility that a mediastinal shadow is caused by an aneurysm of the aorta or pulmonary artery and not by a mediastinal tumour the oesophagus should be outlined with barium sulphate *paste and examined by fluoroscopy to see whether it is displaced or encroached upon in any way* In addition plain right and left anterior oblique views at 60–70 degrees rotation should be taken to outline the aorta thus showing the condition of the vessel and the relation of the shadow to it and to show or exclude vertebral or sternal erosion

A kymogram is sometimes of help particularly if it can demonstrate normal aortic pulsations independently of the shadow The presence or absence of pulsation of the shadow itself is without significance since some tumours show vigorous pulsation and some aneurysms very little



Fig 131—Aortic aneurysm Arrow points to a ring of cal ification round the periphery Female aged 17 years Mass x ray finding No physical signs At thoracotomy it was some time before it was realized that the tumour was in fact an aneurysm

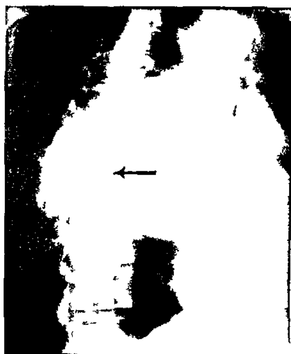


Fig 13 —Aortic aneurysm Arrow points to the verteb l erosion caused by the aorti aneurysm The large circular shadow of the aneurysm is visible around the arrow A trace of barium is seen in the oesophagus which is displaced anteriorly

The *situation* of the shadow should be carefully noted *If it is clearly separated from the aorta* lying for instance well anteriorly on the left side or posteriorly on the right it is probably a tumour Well defined sternal or vertebral erosion extending from the surface gross oesophageal displacement and failure to demonstrate a normal independent aortic shadow will favour the diagnosis of an aneurysm

It is only fair to say that these criteria are not entirely reliable and that differentiation of an aortic aneurysm from the many other causes of abnormal mediastinal shadows is sometimes impossible by radiological examination Fig 131 demonstrates such a case Even at thoracotomy it was some time before it became evident that the well defined circular shadow with a rim of calcium did in fact represent an aneurysm and not a neoplasm Even angiography may be indecisive since these unusual types of aneurysm may fail to fill with the contrast medium either because of a clot or because of the smallness of the opening

ANTERIOR MEDIASTINAL SHADOWS

Anterior mediastinal shadows always lie in contact with or close to the sternum They may be further grouped into those lying very high up those in the upper three quarter and those low down reaching

to the shadow of the diaphragm In the anterior view some are seen to lie centrally and may either be covered by the normal cardio vascular shadow or project some distance beyond it on one or both sides Others such as a paratracheal cyst lie entirely to one side and even their medial border may be several centimetres to one side of the mid line Sometimes the shadow is large wide and rather pear shaped as in a lymphosarcoma sometimes it is smaller and has a well demarcated oval or circular shape as in a dermoid Certain of these characteristic appearances may occasionally assist the diagnosis (*see* Table I and the following comments)

If the shadow is large and lies anteriorly behind the middle third of the sternum and shows no unusual features then an anterior and lateral view will suffice since further radiological investigations are unlikely to help the diagnosis If on the other hand it lies anteriorly in the lower third then a careful search should be made for abnormal gas translucencies both above and below the diaphragm If there is any suspicion of these confirmation or exclusion of a hernia through the foramen of Morgagni should be sought by a barium meal Since a hernia in this region usually contains small intestine or colon the barium meal should be specially timed to outline these parts To save the patient several journeys to the x ray department a double drink is useful The first drink con isting of 6 ounces of barium sulphate emulsion (10 ounces to 1 pint of water) is given about 24 hours before the x ray examinations and the second drink is given in place of breakfast on the day of the examination the first radiograph or fluoroscopic examination being some 2 hours later If the parts are not outlined ordinary meals are then taken and the progress of the barium through the intestine is followed until it can be proved for certain that no gut lies above the diaphragm

TABLE I

CAUSES OF ANTERIOR MEDIASTINAL SHADOWS

Position of shadow	*Cause*
Tending to lie very high up	Retrosternal thyroid Aneurysm of innominate artery Oesophageal pouch
Tending to lie in upper three quarter	The reticuloses Lymphadenoma lymphosarcoma lymphoma leukaemia Secondary deposit Tuberculous glandular abscess Non tuberculous inflammatory abscess or glandular enlargement Ectopic thyroid gland Ectopic parathyroid gland Thymic tumour Dermoid (teratoma) Cystic hygroma Lipoma and other rare benign tumour
Tending to lie touching diaphragm	Parapericardial and pleural cyst Hernia through foramen of Morgagni

Retrosternal thyroid

A retrosternal enlarged thyroid is usually partly palpable in the neck and clinically obvious

The shadow covers the medial half or more of one apex and is seen to extend well below the clavicle It tends to lie more to one side than the other If it lies towards the right side its well defined slightly concave lateral margin will simulate that of an obstructive atelectasis of the upper lobe but there will be no fissure displacement or alteration of the lung vessel pattern

The trachea is deviated away from the side of maximal shadowing is often narrowed and is seen in the lateral view to be displaced posteriorly

The shadow may be difficult to identify in the lateral view but a haziness in the place of the normal retrosternal translucency will be seen The margins of the shadow can be demonstrated in lateral view tomograms

Aneurysm of the innominate artery

An aneurysm of the innominate artery can usually be felt with its expansile pulsation in the lower neck region and can thus be diagnosed clinically It tends to show vigorous pulsation in a kymogram but this feature may not be apparent if the direction of movement is not along that of the grid slits

There is usually marked unfolding or enlargement of the aortic arch If the condition were not so uncommon the difficulties of diagnosis would be more generally appreciated

Oesophageal pouch

An oesophageal pouch large enough to cast a shadow is generally associated with symptoms of a type to suggest the need for a barium swallow which in its turn will prove the diagnosis

The reticuloses

The reticuloses (lymphosarcoma leukaemia lymphadenoma and the like) often give rise to a rather large shadow in the upper half (Fig 133) Commonly this extends either side of the mid line and has



Fig 133—Leukaemia with anterior mediastinal deposits The deposits lay retrosternally extending posteriorly to surround the trachea and inferiorly to encase the heart White blood count 100 000 Blast cells 78 per cent Male aged 13 years Six weeks cough sputum and difficulty in breathing



Fig 134—Lymphad noma with local zed shadow lying on th right side Female aged 53 years Mass x ray finding Lar e encapsulated solid tumour found lying retrosternally which was removed No other mediastinal deposits

well-defined slightly convex lateral margins The superior vena cava is obscured by it There may be slight compression but there is little or no displacement of the trachea The normal aortic shadow may be seen through the tumour shadow in a film taken with a moving grid or in a kymogram If the mass is very large it will surround the upper part of the heart shadow which because it cannot be separately distinguished may appear to be enlarged Frequently the lung fields are clear but the anterior mediastinal shadow may be associated with hilar glandular enlargements especially in lymphadenoma or there may be small areas of ill-defined clouding in the lungs from additional deposits

In a lateral view the normal retrosternal translucency can no longer be seen and this area appears grey relative to the darker retrocardiac area The limits of the shadow are often difficult to see in a plain lateral view radiograph but will stand out clearly in lateral view tomograms If the mass is large it will extend back to and surround the trachea and may even cause slight posterior displacement of it and the oesophagus

The nature of such an opacity may be inferred if a white blood count shows leukaemia or the histology of an enlarged palpable gland after removal shows the characteristic changes of lymphadenoma If on the other hand there are no clinical clues and no gland is available for biopsy a small dose of

therapeutic x rays may be given and if this is followed in 2 or 3 weeks by a marked decrease in size of the shadow it would suggest a diagnosis of a highly radio sensitive tumour such as a lymphosarcoma

Variations of these typical radiographic appearances are occasionally seen In lymphadenoma enlargement of the hilar glands without a visible neoplastic mass in the anterior mediastinum is not uncommon A more rare variation seen in lymphadenoma or lymphosarcoma is that of a single localized oval or circular shadow small at first but later growing to several centimetres in size lying retrosternally often rather to one side of the mid line (Fig 134) In this form the lesion is often without easily accessible clinical manifestations and is therefore indistinguishable from the many other causes of a localized shadow in this situation until the clinical course or its removal at a thoracotomy reveals its nature

Secondary deposit

A secondary deposit may grow in a gland situated in the anterior mediastinum and give rise to a massive well defined opacity in this situation Often the site of the primary neoplasm is obvious on clinical examination but this is not always the case and then distinction from a shadow due to other causes may not at first be possible There is an uncommon form of bronchial carcinoma where the lung neoplasm is so small that it may be inconspicuous or invisible on the radiograph clinically silent and beyond the range of vision on bronchoscopy but nevertheless gives rise to massive secondary deposits and therefore a large shadow in the anterior mediastinal region

Tuberculous glandular abscess

A tuberculous glandular lesion may give rise to a well demarcated large shadow in the anterior mediastinum which is indistinguishable from that caused by one of the reticuloses or a secondary deposit It is a common manifestation of a primary tuberculous lesion in children but may also occur in an adult In the early stages of the investigations there may be very little clinical indication of the nature of the shadow unless there is an associated lung shadow or palpable glands in the neck Sometimes however the diagnosis is quite unexpected and first demonstrated at a thoracotomy

Non tuberculous inflammatory abscess or glandular enlargement

An inflammatory glandular enlargement in the mediastinum of non tuberculous origin or an exudate around it is generally easily recognized clinically A non inflammatory exudate occurring after an operation a thymectomy for example will result in a similar shadow which will resolve in a few days

Ectopic thyroid gland

An ectopic thyroid gland may lie entirely in the retrosternal region with no connexion with the neck except its blood supply which in any case will be invisible on the radiograph The shadow is more often elongated than circular and may be several centimetres wide with its upper margin 1–2 centimetres below the suprasternal notch and its lower margin reaching almost to the xiphisternum (Fig 135)

In a plain lateral view radiograph the shadow may be clearly demarcated and its retrosternal position obvious or it may be poorly defined but its presence will be indicated by the relative greyness of the retrosternal region compared to the darker appearance of the normal retrocardiac region (Fig 136)

There may be no evidence of hyperthyroidism and no other thyroid tissue in the neck If there is a thyroid gland in the usual site in the neck this may or may not be enlarged

Ectopic parathyroid gland

A parathyroid tumour is generally associated with hyperparathyroidism and if this condition is suspected and no tumour can be felt in the neck then one should be sought in the retrosternal region by careful radiography Though small being only 1–2 centimetres in size the retrosternal tumour is usually visible in a plain lateral view or in lateral view tomograms

A thymic tumour

A thymic tumour usually presents as a well demarcated 1 5 centimetre circular or oval shadow lying in the retrosternal region well below the level of the suprasternal notch If the shadow is associated with myasthenia gravis there will be no doubt as to its nature but often there are no symptoms It may lie in the mid line or to one side

Some thymic tumours are large and conspicuous but others may be small and difficult to see without very careful radiography They may be shown in a plain lateral view taken with the patient s hands behind his back with the x ray tube centred 1 inch behind the middle of the sternum and with an exposure that does not give too much blackening Some patients with severe myasthenia gravis cannot take a deep breath with the result that the contrast in the retrosternal space is diminished In cases of doubt the tumour can be more clearly demarcated in lateral view tomograms An artificial pneumomediastinum is not necessary for this purpose



Fig 135—Ectopic thyroid gland in the anterior mediastinum with shadow projecting either side of the heart Female aged 47 years Goitre removed from the neck 7 years previously No hyperthyroidism Removal through the left intercostal space Histology was that of a nodular goitre



Fig 136—Same case—lateral view Arrow poi t hazy opacity of retrosternal region which is grey co nared with the darker normal retrocard ac region The tum r marg are poorly defined An isthmus connected tumour w th remains of goitre in lower neck region

Some of these tumours have small central areas of calcification a feature which may show on the plain radiographs or may only be demonstrated by tomography

Dermoid or teratoma

A dermoid (or teratoma) is usually cystic and clearly demarcated and may attain a size of 12 centimetres or more

It frequently presents as a low density homogeneous shadow similar to the other circular or oval masses found in this situation In some there is a peripheral ring of calcification or a few spots of calcification in the centre Elements of bone or teeth can sometimes be distinguished even in the plain radiographs but these will show most clearly on tomograms

Cystic hygroma

A cystic hygroma is usually situated in the lower half of the retrosternal region and presents as a well-demarcated circular or oval shadow some 4–6 centimetres in diameter

Lipoma or other rare benign tumour

A lipoma or other rare benign tumour is usually in the lower half A lipoma may grow to a very large size and may be lobulated

Parapericardial cyst and pleural cyst

A parapericardial cyst or pleural cyst usually occupies the angle between the sternum and the diaphragm in the lateral view In the anterior view it lies in the cardio phrenic recess if it is on the right side but is usually covered by the heart shadow if it is on the left It may project beyond the apex and simulate the pericardial pad of fat seen in this region in stout individuals It is well demarcated and some 2–3 centimetres in diameter it does not calcify and kymography does not assist the diagnosis These cysts are the commonest cause of a symptomless shadow in this situation

Hernia through the foramen of Morgagni

A hernia through the foramen of Morgagni may result in a shadow retrosternally in the mid line or to one side In addition there may be some abdominal air translucencies lying high up well anteriorly just below the diaphragm a situation in which they are not usually apparent

MID MEDIASTINAL SHADOWS

If the shadow lies in the mid mediastinal region roughly on a level with the trachea or oesophagus the oesophagus should be outlined with barium sulphate paste to see whether it is displaced by the abnormal shadow or related to it in any way If a fluid level or gas translucencies are seen the stomach should be examined with a barium sulphate emulsion to exclude a hernia If the shadow is small and inconspicuous tomograms will be needed to confirm its presence and show its relation to nearby structures such as the trachea Sometimes it is of help to take the tomograms while the oesophagus is still outlined with the barium paste

Causes of Mid Mediastinal Shadows

The causes of mid mediastinal shadows are ectopic thyroid gland the reticuloses enlarged paratracheal glands paratracheal and paraoesophageal cysts cardiospasm and megaoesophagus and hernias

Ectopic thyroid gland

The thyroid gland or an accessory gland may lie within the thorax around the trachea It casts a more or less circular well defined shadow several centimetres in diameter It may displace the trachea forwards and the oesophagus backwards or it may be wrapped round the trachea leaving it in its normal position It is possibly found incidentally in a radiograph when its nature may not be appreciated or there may be symptoms of hyperthyroidism

The reticuloses

The reticuloses may result in a paratracheal instead of a retrosternal mass Multiple paratracheal glandular masses fusing to produce a considerable shadow are not uncommon but more rarely a single circular mass is found 5–10 centimetres in size and its nature only discovered after removal

Enlarged paratracheal glands

Enlarged paratracheal glands may be obvious on the plain radiographs If the enlargement is only moderate they are best demonstrated in lateral view tomograms in which the abnormal shadows may be seen at the same level as the tracheal translucency or in the next layer lateral to it

Needless to say the radiographs will give no clue as to the cause of the enlargement The shadow may be just as well defined in a tuberculous or other inflammatory glandular enlargement as in a sarcoidosis or neoplastic glandular enlargement The presence of associated enlarged hilar glands or pulmonary opacities rarely helps the diagnosis

Paratracheal and paraoesophageal cysts

Paratracheal and paraoesophageal (foregut) cysts are identical on the radiograph and the two conditions cannot therefore be differentiated by this means Either may cause slight indentation of the barium shadow as it fills the oesophagus The shadow is well defined oval and homogeneous measuring

about 4-6 centimetres long and in the anterior view lying to one side of the mid line more commonly to the right than to the left In a lateral view it lies at the same level as the trachea or oesophagus Attempts to differentiate a fluid containing cyst from a solid tumour mass by kymography have not been very successful



Fig 137 —Cardiospasm causing enlargement of the mediastinal shadow Arrow points to the right border of the heart Small translucent areas within the shadow are seen below the clavicle and are due to food and air bubbles contrasted with the fluid in the dilated oesophagus Male aged 49 years Inability to cough freely so chest radiographed Dilatation of oesophagus confirmed by barium meal and oesophagoscopy Heller s operation



Fig 138 —Actinomycosis of right lung Opacity in the upper third due to consolidation No tracheal displacement Arrow points to periosteal new bone on the under surface of a rib The ribs above show a similar change Female aged 6 years Febrile illness with cough and actinomyces in the sputum Lesion spread to spine and meninges with fatal result Post mortem proof of upper lobe consolidation

Cardiospasm and megaoesophagus

The oesophagus may be greatly enlarged as in cardiospasm or megaoesophagus and will then project to the right to form a part or the whole of the right border of the central shadow It may form one continuous slightly convex curve from the clavicle to the diaphragm (Fig 137) or may project beyond the heart shadow only in the upper or lower third Sometimes the shadow is homogeneous sometimes a slightly mottled appearance is seen due to the admixture of fluid solid food particles and air bubbles The nature of the shadow will be readily appreciated either from the symptoms or after a barium meal examination The barium will fall through the residual fluid in the dilated oesophagus in a characteristic manner and will also reveal the degree of enlargement

In a plain lateral view the shadow is often inconspicuous even when the dilatation is enormous but careful inspection of the radiograph will show that the retrosternal translucency is darker than the retrocardiac area which will appear grey This combined with the fact that a barium swallow is indicated in all cases when an abnormal mid mediastinal shadow of doubtful aetiology is seen should lead to the correct diagnosis

Hernia

A hernia generally of the stomach may cast a shadow in the lower half of the mid mediastinal area behind the heart It usually contains gas and perhaps fluid which together with the position of the

shadow are indications for a barium meal examination so that the diagnosis is usually straightforward Sometimes the hernia contains a solid abdominal organ such as a part of the liver spleen or a kidney and the diagnosis may then be more difficult A pneumoperitoneum will assist the diagnosis in a difficult case and may indicate the abdominal origin of the contents of the hernia

A hernia of the stomach large enough to give a shadow on the plain radiograph will fill readily with barium if the patient is lying down and there will be no need to tilt him at an angle head downwards It is important however not only to make the diagnosis but to show the type of hernia and any associated features such as regurgitation or ulceration When the part of the stomach lying in the thorax is outlined with barium a second drink is given with the patient lying down to outline the oesophagus a second time and show its relation to the stomach and diaphragm This will also show any shortening of the oesophagus and any secondary oesophageal changes such as dilatation narrowing irregularities of outline indicating oesophagitis or projections indicating ulcer craters

The presence or absence of regurgitation of the barium from the stomach into the oesophagus should be carefully investigated with the patient lying standing and stooping down If regurgitation is very free the possibility of some relationship of the hernia to any abnormal intrapulmonary shadow suggesting an aspiration pneumonia should be considered

If the oesophagus is full length and pierces the diaphragm an attempt should be made to measure the size of the defect through which the stomach enters and returns from the thorax This may be gauged from inspection of anterior and lateral views provided the connexion between the thoracic and abdominal parts of the stomach can be outlined with the barium If the defect is so large that it cannot be defined with certainty it may be difficult to differentiate a hernia passing through a very large central defect in the diaphragm from a gross elevation of the diaphragm especially if the stomach is rotated round under this In the latter condition the upper margin of the shadow tends to be marked by the very even thin bow line of the raised diaphragm whilst a hernia tends to have a flatter more irregular margin If there is some functioning muscle around the defect contractions of this more or less at the usual level of the left dome may indicate the true state of affairs

A hernia may result in temporary obstruction of the stomach which then becomes much distended with air and may occupy the whole of the left thorax and thus simulate a spontaneous pneumothorax or hydropneumothorax should there be some fluid in it (Fig 122) If the obstruction is not relieved spontaneously the onset of severe clinical symptoms will suggest the diagnosis

POSTERIOR MEDIASTINAL SHADOWS

If the shadow lies posteriorly an additional view of the posterior part of the ribs nearby may be needed to demonstrate any splaying out or bone erosion If the shadow extends to the vertebral margin th vertebrae in its neighbourhood should also be radiographed and sometimes even demonstrated in tomograms to see whether there is any erosion or splaying out of a pedicle

Causes of Posterior Mediastinal Shadows

The causes of posterior mediastinal shadows are neurofibroma (neurilemmoma) ganglioneuroma dermoid paravertebral abscess paravertebral neoplastic deposit and hypertrophy of paraspinal marrow deposits

Neurofibroma (neurilemmoma)

An isolated intrathoracic neurofibroma arising from an intercostal nerve or the sympathetic chain may be found at any level between the first and twelfth ribs but is most frequently seen in the upper two thirds Characteristically it lies posteriorly to one or other side of the mid line and even when it attains a large size there may be no vertebral or rib changes or at the most only slight splaying out and pressure erosion of a rib The shadow is homogeneous without calcification oval in shape and with a well defined lateral convex margin

These lesions are for the most part clinically silent They are generally single but occasionally two are seen one below the other giving a dumb-bell shaped shadow (not to be confused with a dumb-bell

tumour) In rare instances a single one is situated peripherally against a rib in the axilla A fibroma of the visceral pleura gives a similar shadow (*see* p 62)

Ganglioneuroma

A ganglioneuroma is more likely to cause pressure erosion of a vertebra or rib and splaying out of the ribs If there are any clinical indications of intraspinal extension careful radiography of the vertebra in the neighbourhood of the shadow is indicated including tomograms Erosion or broadening of a pedicle may suggest that the intraspinal portion should be removed prior to the intrathoracic part of the tumour Sometimes deep seated calcifications are seen in the tumour

Dermoid

A dermoid may be situated posteriorly and may show the shadows of bone or teeth within it to indicate its nature

Paravertebral abscess

A paravertebral abscess may be present even in the absence of radiographic changes in the inter vertebral spaces or in the bones It may lie in the same position as a neurogenic tumour but can *generally be distinguished from it because the lateral margin is straighter It is more likely to be mistaken for a collapsed lower lobe than a tumour but there will of course be no fissure displacement* or alteration in the pulmonary vessel pattern

Paravertebral neoplastic deposit

A paravertebral neoplastic deposit especially in lymphadenoma will result in a shadow indistinguish able from an abscess but its nature will usually be known from the clinical findings

Hypertrophy of paravertebral marrow deposits

Hypertrophy of paravertebral marrow deposits may occur in some cases of haemolytic anaemia and result in a shadow like a neoplastic deposit alongside the lower thoracic vertebrae

THE DIAPHRAGM SHADOW

If a diaphragmatic hernia is present and contains some gut the presence of gas translucencies will often suggest the diagnosis which can then be confirmed by a barium meal A localized bulge in the middle third of the right dome may be caused by a portion of liver protruding through a gap where he muscle is deficient for 1–2 centimetres The herniated portion of liver may spread out after passing through the diaphragm to produce a 2–3 centimetre circular shadow with its base on the diaphragm A similar shadow may be caused by a localized weakness of the muscle which nevertheless remains intact The liver bulges up with it but there is no hernia

A diagnostic pneumoperitoneum is indicated in some cases to try and determine the exact anatomical site of the abnormal shadow If after the induction of the pneumoperitoneum air can be seen between the liver and the diaphragm it will be possible to see whether the shadow encroaches upon the air translucency suggesting a cyst or tumour whether it is entirely intrathoracic or whether only a thin band like shadow separates the lung from the intraperitoneal air translucency indicating a local weakness of the diaphragm or a small hernia If the air does not intrude between the diaphragm and the shadow caution should be observed in the interpretation of the x ray appearances since old peritoneal adhesions or an anatomically short peritoneal recess may limit the spread of air and give a false impression of the position of the diaphragm

A localized bulge of the diaphragm may be caused by an intra abdominal lesion such as a sub-phrenic abscess liver abscess hydatid cyst or tumour Sometimes an intra abdominal lesion can be seen below a normal diaphragm shadow such as a clinically unsuspected spontaneous pneumoperitoneum or gut abnormally distended with gas or lying in an unusual position Gas trans lucencies from a loop of gut between the right dome of the diaphragm and the liver are seen occasionally and are of no importance except that they would make a liver biopsy hazardous for instance in a case with pulmonary shadows suggesting sarcoidosis

An abnormal low-density shadow such as an unsuspected splenic enlargement or high-density shadows suggesting calcifications in the liver or spleen associated with abnormal mediastinal or lung opacities may have importance in the diagnosis of an obscure chest shadow

At times an intra abdominal condition presents clinically as an intrathoracic lesion and the finding of an intrapulmonary or pleural shadow must not distract attention from the inspection of the sub-diaphragmatic region in a chest radiograph A companion shadow running with that of the right cupola of the diaphragm may be seen if it casts a shadow separate from that of the liver an appearance which may result from abnormal radio opacity of the liver in such a condition as haemachromatosis

CHAPTER 7

BONES OF THORAX, SOFT TISSUE COVERING AND REMOTE BONE LESIONS IN CHEST DISEASES

CAREFUL inspection of the bones and extrathoracic soft tissues adds considerably to the time taken to examine a chest radiograph and is impracticable as a routine These shadows should at least be given a perfunctory glance in every radiograph and in all difficult cases they should be inspected with care

If a rib lesion is suspected but no abnormality can be seen in the routine anterior view radiograph or if an abnormality is present but not clearly seen then additional radiographs should be taken More detail of a suspected abnormality in a rib may be obtained by the use of a coned down view by an oblique view centred on the affected area with the affected part of the rib as nearly as possible parallel to the film and by using a Potter Bucky diaphragm A view on expiration is also useful in some cases to show whether a doubtful shadow does in fact move with the rib or is independent of it In many cases tomograms are of value and may reveal periostitis erosion or the presence of a sequestrum which was invisible in the plain radiographs

PERIOSTITIS OF RIB

Periosteal new bone formation along a rib may result particularly from trauma or infection it may be the only radiographic evidence of disease or other changes may also be present It appears as a hair line shadow or a shadow 2–3 millimetres wide running parallel to the rib In its early stages it is separated from the cortex by a zone of translucency 1–2 millimetres wide but at a later stage it will tend to merge with the cortical bone

Where the rib is much curved it tends to lie or be most easily seen on the medial concave surface but when situated on the straighter portions of a rib it is often seen on both sides

The shadow of periosteal new bone must be distinguished from the various soft tissue companion shadows (*see* p 19) which are generally bilateral and symmetrical and from the normal osseous ridge on the under surface of the posterior third of the rib This latter shadow may be unduly conspicuous if there is slight rotation of the rib as a result of local retraction of the chest wall or of scoliosis the presence of which should be apparent on the radiograph

PERIOSTITIS SECONDARY TO EMPYEMA OR ACTINOMYCOSIS

Periosteal new bone should be sought in those ribs adjacent to any large long standing pleural shadow or any pulmonary shadow of unknown aetiology The combination of a shadow suggesting a large area of pulmonary consolidation with periostitis of the overlying ribs will suggest a diagnosis of actinomycosis (Fig 138)

PERIOSTITIS FROM TRAUMA

Periosteal new bone should also be sought in cases of local chest pain or tenderness especially if there are no clinical clues as to the cause and no abnormal lung shadows or translucencies in the radiograph which might account for it Careful inspection of the ribs in the general area of the pain is often rewarding The tell tale white line of periosteal new bone or the shorter broader half moon protuberance of a haematoma or of calcifying callus may be the first evidence of a stress or cough fracture the fracture line itself being seen only on subsequent radiographs at a later date

PERIOSTITIS IN OSTEOMYELITIS

More rarely a localized area of periostitis may be the first radiological indication of primary osteomyelitis of a rib the presence of which may have been ushered in a few days previously with a

dramatic onset of fever and malaise but not necessarily with obvious local physical signs Such an inflammatory lesion may result in an unusual looking shadow over the lung due to the surrounding extrapulmonary abscess which is easily mistaken for a pleural or lung shadow

Sometimes osteomyelitis of a rib is less acute and may follow weeks or months after a traumatic incident without any infringement of the skin surface In such a case as well as in the more acute manifestations of the disease the localized areas of periostitis may be associated with bone erosion or even a sequestrum

RIB FRACTURE

Traumatic Fracture

A fracture of a rib will be quite conspicuous if there is displacement of the fragments If there is no displacement the dark translucency of the fracture line may not be easy to see unless carefully sought and may be detected more readily if a magnifying glass is used It may also be seen if attention is drawn to it by the finding of a ring or half moon shadow of periosteal new bone bordering on the rib or if there is any evidence of local disease of the rib A fracture may be the result of known trauma the patient being acutely conscious of the incident or it may be a spontaneous fracture The latter may also be due to trauma so slight that the patient was unaware when it occurred as for instance trauma during a bout of coughing or a lurch against an object when consciousness was dulled by sleep or alcohol

Stress Fracture

In another condition known as a stress fracture there is an appearance suggesting a fracture line across the bone usually with a 1 millimetre rim of dense bone adjacent to it and a small bulge due to periosteal new bone at the edges It is possible that the condition is not a fracture at all but a linear zone of decalcification This condition usually occurs in the first rib but can occur in other ribs and it is usually asymptomatic Union or reforming of the calcified elements is very slow and may take a year or more

Post Radiation Fracture

Following x ray therapy ribs in the main field of irradiation may become unduly brittle For instance fractures in a line along the anterior ends of several contiguous ribs are sometimes seen in a patient who has had a glancing field of irradiation in this region for a carcinoma of the breast

Pathological Fracture

A fracture may be seen through an area of abnormal bone particularly through the small erosion of an early secondary deposit It may occur of course through an extensive erosion of a more advanced secondary deposit or an erosion due to any cause including a myelomatosis

A spontaneous fracture of a rib may also occur in any general bone disease causing a generalized brittleness of the bones In fact a routine radiograph of the chest showing multiple rib fractures may be the first evidence of some such general condition for example Cushing s syndrome The abundant circular masses of calcified callus in this or a similar condition must not be mistaken for intrapulmonary secondary deposits

RIB EROSION

Benign Tumour

A well defined localized area of rib erosion that is an area of calcium absorption or actual bone destruction is seen in a cyst or benign tumour The translucent zone is often well demarcated by a white line due to condensed or sclerotic bone whilst if the lesion causes a local expansion of the bone the cortex remains intact over it In a cyst the radio translucency is uniform but in a chondroma small white spots may be seen due to small areas of calcification in the cartilage In an osteo-chondroma larger areas of opacity are seen partly due to the formation of bone which will show evidence of trabecular structure and partly due to calcification in the cartilage

Xanthomatoses

A well demarcated erosion but often without a complete ring of condensed bone around it and perhaps even with a breach of the cortex is seen with a lipoid deposit in a patient suffering from one of the xanthomatoses particularly an eosinophil granuloma A rib erosion in a xanthoma is sometimes associated with deposits in the lungs resulting in a fine reticular or net like pattern in the lower two thirds There may be deposits in other bones—the skull pelvis femora or humeri being the most common sites These bones should therefore be radiographed if a rib erosion or lung reticulation is seen of unknown aetiology

Primary Malignant Rib Tumour

The x ray diagnosis of a primary malignant rib tumour is not always easy or reliable The erosion may be well demarcated and this together with a localized well defined area of bone expansion may suggest a benign tumour Fig 139 illustrates such a case The lesion was found on mass radiography and was asymptomatic A slight swelling could be felt and although the radiographic features indicated a benign lesion the anterior part of that rib together with the tumour were removed It was then found that the tumour was a *sarcoma with tumour cells invading the nearby intercostal muscle* Other similar cases have emphasized the difficulty of guessing the histology of rib tumours from the radio graphic appearances

In another type of primary malignant bone tumour of a rib the amount of bone destruction is much greater and the area of erosion is poorly demarcated It tends to be of the purely erosive type but sometimes some faint line shadows or feathering can be seen at right angles to the cortex Differentiation from a secondary deposit is not always possible while if the tumour has invaded the soft tissues around producing a 2–5 centimetre low density shadow differentiation from a bronchial carcinoma invading the rib and surrounding tissues of the chest wall may not be possible from the radiographs

Rib Secondary Deposits

A secondary deposit in a rib usually causes a poorly demarcated area of erosion without a line of condensed bone around it and without any bone expansion There is no periosteal reaction although this may be simulated by the calcifying callus should a spontaneous fracture pass through the area of erosion

It may be isolated or there may be deposits in several ribs It is not a very common finding in a bronchial carcinoma but the presence of such a rib erosion might discourage the performance of a pneumonectomy in some cases Erosions from secondary deposits may of course be seen in any of the bones which are included in a chest radiograph They are not uncommon in the clavicle or the scapula particularly in the region of the superior or inferior angle and may be seen in a vertebra in the lateral view

Tuberculosis of a Rib

In a tuberculous lesion of a rib bone erosion is the predominant feature and is generally poorly demarcated extending over an area of 1–2 centimetres It may be associated with some periosteal new bone but this is often either absent or of slight extent The lesion may occur in any part of the rib A not unusual feature of tuberculosis affecting the anterior end of the rib is the presence of extensive caseation and clinical evidence of swelling without any visible changes in the radiographs

Acute Osteomyelitis of a Rib

A small area or several contiguous small areas of bone destruction may precede the appearance of periosteal new bone deposits in osteomyelitis This will only last for a few days before the periosteal reaction becomes obvious so that confusion with a secondary deposit is unlikely to occur

Pressure Erosion of Ribs

Small pressure erosions from tortuous dilated intercostal vessels acting as collateral channels are seen in coarctation of the aorta and are easily overlooked unless they are suspected They are seen on the inferior borders of the posterior horizontal parts of the ribs most commonly in the region of the fifth to the eighth ribs *If they are seen in a radiograph they may be the first finding to draw attention to the condition* They are demarcated by a thin layer of compact bone which has a rather wavy outline

STERNAL EROSION

Erosion of the sternum is usually due to secondary deposits but a rather similar erosion is seen as a late manifestation of syphilis In either condition the erosion may be seen in a lateral view of the chest before a lesion is suspected clinically Sometimes the erosion is so extensive that no sternal shadow can be seen and its absence may pass undetected on the radiograph A more localized erosion may be caused by a smaller secondary deposit or a gumma Pressure erosion may also occur with an aortic aneurysm and is generally well demarcated whilst the shadow of the aneurysm will be obvious A small sternal lesion is most easily seen in oblique views or in an oblique view tomogram



Fig 139 —Sarcoma at the anterior end of the third right rib Male aged 30 years Mass x ray finding Removal of rib Poorly differentiated spindle-celled osteogenic sarcoma destroying bone and infiltrating the muscle

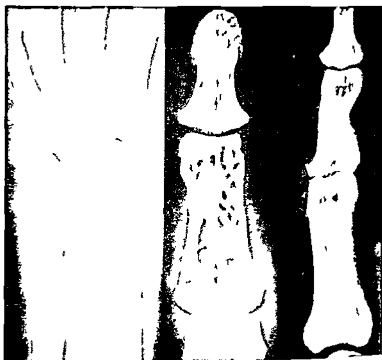


Fig 140 —On left—pulmonary osteoarthropathy Wrist showing periosteal new bone on radius and ulna Male aged 50 years With joint pains Three centimetre bronchial carcinoma After removal rapid resolution of bone changes Centre—finger in a case of sarcoidosis with pulmonary shadows Finger swollen and much pain On right—finger in another case of sarcoidosis with pulmonary shadows

INCREASE IN DENSITY OF RIB

An isolated increase in the density of a rib without any other changes is usually due to a developmental defect dense bone being substituted for cancellous bone Such a change is without clinical significance A localized increase in density with some thickening of the bone and an alteration in the trabecular architecture is seen in Paget s disease A more generalized increase in density which may be either diffuse or patchy is seen in some generalized bone diseases such as marble bones (osteopetrosis) generalized Paget s disease or sclerosing secondary deposits especially from the prostate In sclerosing secondary deposits there may also be widely disseminated areas of patchy clouding in the lungs and without tomography it is sometimes difficult to see which shadows are in the lung and which in the ribs

DISPLACEMENT OF RIBS

Local rib retraction is frequently seen overlying an area of lung disease and is usually apparent on clinical inspection of the chest A severe kyphoscoliosis will result in such crowding together of the ribs that together with the shadow of the vertebrae it may make the plain anterior view radiograph

useless for the detection of a chest lesion In such a case some help may be obtained from oblique views or tomograms

Local spreading out of the ribs may occur over a large lung or mediastinal tumour or over a large pleural effusion

SOFT TISSUE COVERINGS

A tumour or an inflammatory mass in the soft tissue coverings of the thorax may result in a shadow overlying the lungs in one view a localized tumour in particular may result in a circular shadow simulating an intrapulmonary lesion Its extrathoracic position will however either be apparent on clinical examination or radiologically when a lateral view or tomograms are taken to localize the position of the shadow

Gas translucencies in the extrapleural spaces are described on p 96

REMOTE BONE CHANGES ASSOCIATED WITH INTRATHORACIC DISEASE

Pulmonary Osteoarthropathy

Sometimes certain lung diseases are associated with bone lesions outside the thoracic cage The association of pulmonary osteoarthropathy with a bronchial carcinoma or a fibroma of the lung or pleura has been referred to on p 62 It is also occasionally seen in association with a long standing intrathoracic inflammatory condition such as a chronic lung abscess or empyema

Pulmonary osteoarthropathy is sometimes found accidentally when a bone is radiographed for some other purpose for instance to exclude a fracture after trauma but it is more often seen because pain or swelling in or near a joint draws attention to the condition If it is suspected because of the lung shadow but there is no obvious pain or swelling an anterior view radiograph should be taken of a hand and wrist and a posterior view radiograph of the knee including the lower third of the femur an ankle including the lower third of the tibia and a foot for the metatarsals

These radiographs will show the periosteal new bone as a 1 2 millimetre shadow round the shaft of the long bones starting 1–2 centimetres beyond the joint and extending some way along the shaft (Fig 140) The shadow tends to merge with the cortex but may be separated from it by a narrow translucent zone *Even when clubbing is gross the phalanges are usually unaffected or if they are* involved the changes are much less marked than in the metacarpals and metatarsals

Sarcoidosis

Of the many cases of sarcoidosis in which pulmonary shadows are present very few show any bone changes When they are present they are most commonly seen in the metacarpals and phalanges and take the form of well demarcated cyst like areas (Fig 140) There is no periosteal reaction and no surrounding decalcification There may be no clinical evidence of the lesion or there may be local pain and swelling *Occasionally similar well demarcated erosions are seen in other bones* even including the vault of the skull

CHAPTER 8

COMBINATIONS OF DIFFERENT SHADOWS

IN THE foregoing sections cases have been described in which a single shadow is seen on the radiograph as in a peripheral neoplasm or multiple shadows of similar size and density as in miliary tuberculosis Sometimes there are several kinds of abnormal shadow together in one radiograph and the particular combination in each case may be a valuable factor in the diagnosis or may give a clue to some particular feature of the underlying pathological changes

SMALL CIRCULAR SHADOWS AND ILL DEFINED LARGER SHADOW

A case in point where the combination of shadows is an aid to the diagnosis is that of the 2–3 centimetre ill defined area of clouding—or the larger shadow with irregular borders and line shadows radiating out from it—of an area of massive fibrosis The x ray diagnosis of either of these shadows will only be substantiated if in addition to the relevant occupational history indicating the possibility of a pneumoconiosis there are also the small widely disseminated low density circular shadows of the basic lesion

SMALL CIRCULAR SHADOWS WITH HILAR GLAND ENLARGEMENT

When small circular shadows or a mixture of circular and line shadows are seen in the lungs the demonstration of enlarged hilar glands if necessary by tomography will be of value in the diagnosis This particular combination of shadows together with a certain clinical picture will strongly suggest sarcoidosis although it is not pathognomonic nor does the absence of glandular enlargement exclude this interpretation Similar appearances are seen in some cases of tuberculosis glandular fever and secondary deposits

SMALL CIRCULAR SHADOWS AND LINE SHADOWS

A combination of small circular shadows with a few rather long line shadows cutting across the vessel pattern is seen particularly in lymphangitis carcinomatosa This condition is rarely demonstrable on the radiographs until the terminal stages when only a few weeks of life can be expected The same radiographic appearances in a relatively fit patient will therefore suggest some other cause such as lymphatic obstruction in any lesion with nodular lung shadows

LARGE CIRCULAR SHADOW WITH SMALL SATELLITE SHADOWS

The presence of some small circular shadows (satellite shadows) in the neighbourhood of a large circular shadow may be the only pre operative point in favour of a diagnosis of tuberculosis rather than neoplasm They are not pathognomonic of either condition but are found much more commonly in tuberculosis The satellite shadows near a neoplasm may be due to superadded inflammatory changes or to small groups of neoplastic cells possibly the result of a local bronchial dissemination

AREAS OF CLOUDING AND RING SHADOWS

A combination of 2 5 millimetre circular shadows or ill defined areas of clouding with a ring shadow indicating a cavity together with some line shadows or a crowding of the vessel pattern is a very common feature in tuberculosis It is often an expression either of the different dates of origin of the various foci or of superadded incidents of mechanical rather than bacterial origin such as a local bronchostenosis producing a tension cavity or airless shrunken lobe or the contraction of fibrous tissue producing an aerated but shrunken lobe

Small Circular Shadows and Tubular Shadows

The combination of low density circular shadows with tubular shadows in the same area will suggest caseous foci associated with bronchiectasis which itself may be tuberculous or a simple distension due to local mechanical factors

High density and Low density Shadows

A combination of shadows of high density due to calcification in the lesions with shadows of lower density is particularly common in tuberculosis It will indicate that some of the foci have progressed towards resolution and quiescence but in general the demonstration of calcification will not appreciably affect the prognosis or influence the plan of treatment In a series of asymptomatic patients over the age of 30 years with small (minimal) lesions the percentage of cases in which the disease spread or in which tubercle bacilli could be isolated was less when calcification could be seen in the initial radiograph than when no calcification could be seen (*see* p 91) Such statistical information is however often of little value in handling the individual case

If the calcium is superimposed on or is near other abnormal shadows tomography may be indicated to see how it is related to these Should the calcification be shown to lie within the wall or lumen of a cavity or bronchus it may influence the decision as to the plan of treatment to be adopted

There are several conditions other than tuberculosis in which calcified lesions are seen in combination with neighbouring low density shadows such as an old abscess or empyema a blood clot in the pleura or a lung cyst histoplasmosis or even some pneumoconioses Even assuming calcifications represent long standing regressed tuberculous foci they will not always assist a comprehensive diagnosis for the associated low density shadows may represent sarcoidosis or a neoplasm either of which can occur even in the presence of calcified foci

Since tubercle bacilli may be found in the sputum when a neoplasm is present as well the hazards of x ray diagnosis need no stressing especially when a combination of shadows is present It is wise to study each type of abnormal shadow and consider it separately in its possible relation to the clinical picture and not to take into consideration only the most obvious or most diagnostic looking shadow

Shadow of Neoplasm and of Complicating Lesion

In a bronchial carcinoma the shadow of the neoplastic mass is frequently associated with ot[illegible]nore distally situated shadows which are the result of a bronchostenosis or vascular occlusion cau[illegible] it If the bronchostenosis is severe there will be a shadow due to the shrunken airless atelectat[illegible]ment or lobe the appearances of which are described on pp 42–59 Usually the oval or [illegible] shadow of the neoplasm is merged into that of the shrunken lobe but the former can some[illegible]nes [illegible] separately identified if it causes a local prominence of the proximal end of the opacity

If the bronchostenosis is incomplete it will commonly result in distal inflammatory changes without atelectasis Small areas of consolidation will result in a group of small poorly defined circular shadows *in a single segment or lobe which may be indistinguishable from tuberculous foci (Fig 106) Such* shadows may be seen together with the shadow of the neoplasm but the latter is often invisible on the plain radiographs although it may be seen in tomograms More severe distal inflammatory changes will produce consolidation of the whole lobe the appearances then being similar to those described on pp 35–42

Another change resulting from the bronchostenosis is bronchiectasis This change which is frequently seen will give rise to tubular shadows if the dilated bronchi contain air or to gloved finger and band like shadows if they are full of secretions which cannot be expectorated Again the shadow of the neoplasm may be invisible in the routine radiographs but may be seen in a film with more exposure or in tomograms

If the neoplasm is rather peripheral and occludes bronchi of the fourth or fifth generation a lobulated shadow may be seen resulting partly from the neoplasm partly from an adjacent dilated bronchus filled with secretion and partly from an area of pneumonia

Finally the distal inflammatory changes may develop into a lung abscess This will show as a translucent zone in the area of opacity usually about 1–2 centimetres in size though it may be much larger or as a well defined ring shadow with or without a fluid level Again the shadow of the neoplasm

may be clearly visible nearer the hilum or it may only be seen on tomograms or the bronchial stenosis *may only be demonstrated on bronchoscopy or in bronchograms*

A neoplasm may press on or invade a branch of the pulmonary artery producing an area of infarction or this may arise without the vessel narrowing being demonstrated The shadow of such a lesion may be merged with that of the neoplasm or the distal atelectatic or inflammatory changes or it may cast a separate 1-2 centimetre circular shadow remote from the neoplasm or a larger wedge shaped shadow with its base in the axilla and its apex towards the hilum where the shadow of the neoplasm will also be seen

Sometimes the shadow of the neoplasm is associated with the shadow of a complicating pleural effusion The combination of a shadow suggesting a neoplasm and pleural effusion does not necessarily indicate that the neoplasm is involving the pleura and is therefore perhaps unsuitable for resection since the effusion may be secondary to the distal inflammatory changes

The shadow of a neoplasm may be seen combined with an abnormal appearance of the vascular pattern such as that seen in emphysema and this may indicate the double diagnosis and influence the line of treatment

The shadow of a neoplasm may be combined with local rib erosion suggesting direct involvement or with erosion of a rib in some other part indicating a secondary deposit In either case such a finding will indicate a poor prognosis

Lung Shadow with Periostitis of Rib

A lung shadow indicating an area of consolidation together with some periosteal new bone formation of several adjacent ribs overlying the shadow will suggest actinomycosis (Fig 138)

CHAPTER 9

BRONCHOGRAPHY

TECHNIQUE OF BRONCHOGRAPHY

BEFORE introducing the contrast medium for bronchography the operator should see that suitable and recent plain radiographs are available and should inspect them carefully From these and from the clinical picture he will be able to decide which parts need filling and in what order this should be done

The choice of contrast medium will depend to some extent on a knowledge of the case since at the date of writing the ideal medium is not yet available In non tuberculous cases especially bronchiectasis iodized oil has certain advantages over the other media being less irritating and tending to penetrate more easily into the diseased areas than propyliodone preparations On the other hand in tuberculosis and many other conditions where opaque iodized oil residues would be particularly unwelcome oily propyliodone (dionosil) is indicated

This medium being more irritating locally than iodized oil there is a greater tendency for the patient to cough or else to be rather less co operative because his attention is concentrated on suppressing the desire to cough Filling of the appropriate bronchi and the production of good radiographs therefore requires rather more skill than when using the older medium

PRELIMINARY TEST FOR IODINE SENSITIVITY

A preliminary test for iodine sensitivity may sometimes be carried out if iodized oil (Lipiodol Neo Hydriol and the like) is going to be used though it is often omitted and is unnecessary if propyliodone is the medium of choice

One such sensitivity test is to give the patient 5 grains of potassium iodide by the mouth 2 days before the bronchography If he is unduly sensitive considerable watering of the eyes and running nose will occur within 24 hours This sensitivity test is not altogether satisfactory A very severe reaction is uncommon in any case and may occur unexpectedly 10–14 days after the bronchography Even if there was no undue reaction at the sensitivity test occasionally when a full bronchography has been carried out after due consideration in spite of an adverse test the patient has after all experienced no untoward reaction

Should the patient be known to be unduly sensitive to iodine brominized oil may be used as an alternative but since reactions to propyliodone are unlikely this medium may be used

PREPARATION OF THE PATIENT

Whatever method or medium is used careful preparation of the patient will be an important factor in obtaining satisfactory bronchograms

Excessive secretions should be reduced as much as possible by preliminary chemotherapy and postural drainage Normal secretion may be reduced by an injection of atropine $\frac{1}{100}$ grains (0 65 milligrams) 1 hour before the examination but is rarely effective in patients with excessive secretion

Reassurance and sufficient explanation of the procedure as is suitable should be given to the patient to gain his co operation and confidence He should be shown the position of the cassettes and trained to take up the positions in which he will be required to stand or lie especially if the radiography is to be carried out in a room with which he is not familiar If the examination is to be carried out under a general anaesthetic this will not be necessary but the appropriate preparation for the anaesthesia will be needed

ORDER OF FILLING OF BRONCHI

If both sides are to be filled at one session it is best to fill the right side first and take a right lateral view as well as an anterior (or posterior) view This will ensure that a satisfactory view of the middle

lobe and apical lower lobe bronchi is obtained without obscuration by shadows from the left side Later when the left side is filled a left posterior oblique view is taken instead of the lateral and in this view the lingula will be displayed and the orientation of the other branches can thus be determined If after a rapid inspection of the wet films it is felt that a left lateral view would be of help the bronchi of the left side can still be shown in a left lateral view in spite of the right sided filling by taking a left lateral tomogram with a multisection box (*see* p 172)

Introduction of Contrast Medium

The technique for the introduction of the contrast medium is best learned under the supervision of someone who has already acquired the necessary skill and experience

There are several methods of injecting the contrast medium and the choice will depend in the first place on the age and condition of the patient In the case of a co operative adult requiring neither a general anaesthetic nor selective filling of one lobar bronchus the method chosen should be that which the operator finds easiest

Whichever method is used the patient must be persuaded to breathe evenly but not deeply during and after the injection and must not cough until after the radiographs have been taken and seen to be satisfactory All patients should be told not to eat or drink anything for 4 hours after the injection as the anaesthetized larynx may permit food or drink to pass into the trachea

Crico thyroid route

A small area of the skin and subcutaneous tissue in the front of the neck is anaesthetized with 2 per cent procaine The trachea is then anaesthetized by the injection of 1 millilitre of 4 per cent lignocaine (Xylocaine) down a needle or down the cannula passed through the crico thyroid membrane followed in 1 minute by a similar injection

The contrast medium is then injected through the needle or cannula with the patient reclining backwards at an angle of 30 degrees and slightly towards the side it is desired to fill A sufficient *dosage for one side is 10–15 millilitres and it should not be warmed or it will be too fluid* and run too rapidly into the smaller bronchi

Intubation via the larynx under general anaesthesia

Intubation via the larynx under general anaesthesia is the method of choice when the patient is a young child The following technique has given consistently satisfactory results in the hands of experienced anaesthetists Premedication given 1 hour prior to induction is measured in minims drawn from a standard 1 millilitre ampoule containing $\frac{1}{3}$ grain of papaveretum and $\frac{1}{150}$ grain of scopolamine The dose is 1 minim per year of age This amount seldom causes sleep but the child is calm and co operative

After induction with nitrous oxide and oxygen ether is cautiously administered until the third plane is reached Laryngoscopy is then performed a long straight spray inserted into the trachea and 1 or 2 millilitres of 4 per cent lignocaine (Xylocaine) injected An endotracheal tube fitted with a Magill or Cobb suction union is then inserted and maintenance of anaesthesia continued with nitrous oxide oxygen and trichlorethylene The ether bottle is removed from the machine

A cautious induction will minimize coughing while topical analgesia of the trachea will tend to prevent *bronchospasm both of which are prone to occur in a patient with a chronic* chest disease The endotracheal tube facilitates the removal of excessive secretion by suction through a catheter In bronchiectasis much secretion is often removed by this procedure even in cases which appeared to be dry following preliminary chemotherapy and postural drainage

A soft rubber or gum elastic catheter is then passed down the Magill suction union and endotracheal tube and should be of such a size that it does not fit the latter tightly The catheter is marked so that it is possible to see when the tip lies just distal to the end of the endotracheal tube This is important since if the tip of the catheter lies in the tube the contrast medium may block the lumen and thus the airway whilst if inserted too far it may enter the right main bronchus and prevent filling of the left side The contrast medium is injected and the patient postured to fill the various segmental bronchi

Since the radiographs are taken while the patient is unconscious co-operation with the anaesthetist is essential to ensure freedom from excessive respiratory movement Controlled respiration enables

the exposure to be made during suspended inspiration but also involves a tendency for the contrast medium to be blown too far down the bronchial tree into the peripheral bronchioles Perfectly adequate radiographs can be obtained during quite spontaneous respiration The exposure is made towards the end of inspiration or of expiration the latter being the longer period without chest movement If respiration is quiet an adequately sharp image of the filled bronchi will be obtained with an exposure of 0 04 seconds If the patient develops a rapid respiratory rate during trichlorethylene anaesthesia intravenous thiopentone is given prior to exposing the films, 0 1 gramme (2 millilitres of a 5 per cent solution) is injected into a dorsal vein of the hand and repeated if necessary If apnoea develops intermittent compression of the reservoir bag is carried out until respiration returns

If after inspection of the first series of radiographs tomograms are indicated it may be necessary to inject a further small dose of thiopentone to ensure very quiet respiration during the 2 second exposure which will be needed

At the conclusion of the examination a thorough tracheo bronchial toilet is performed an artificial airway inserted and the child returned to the ward in the lateral position with the head low

Intubation via the larynx without general anaesthesia

This is a useful method for a person doing bronchography only occasionally provided he has a co-operative adult patient The mucosa of the upper respiratory passages is anaesthetized by spraying on a local anaesthetic such as lignocaine 4 per cent Four millilitres are used for the tongue pharynx and nostril and another 4 millilitres are then sprayed into the opening of the larynx A few minutes later a soft rubber catheter is passed through the larynx into the trachea and the contrast medium is injected through it over a period of about a minute the patient reclining towards the side to be filled The catheter is kept in position during posturing and radiography so that it can be used as a channel for filling the other side a few minutes later

A variant of this method can be used to obtain highly selective filling of a single lobar or segmental bronchus The *tip of the catheter is placed under bronchoscopic or fluoroscopic control in* or *just* opposite the lumen of the bronchus it is intended to outline and 5 millilitres are then injected into it or rather less if only a segment is being outlined In most cases it is necessary to prove th[illegible] the surrounding regions are normal even if the disease on the plain radiographs appears to be [illegible]tined to a single segment and there are therefore few indications for such very selective filling

Nose drip method

In the nose drip method the patient sits on the x ray couch with his head tilted back[illegible] and 2 millilitres of 4 per cent Xylocaine are run into the nostril and from there some travels [illegible] the pharynx causing some coughing Another 2 millilitres of local anaesthetic are then instilled [illegible] nostril and the tongue is held well forwards with a swab *to encourage some of the solution to ent[illegible]* the larynx The contrast medium is then injected into the nostril and if the tongue is held well forward it too will pass down the anaesthetized pharynx and larynx into the trachea With this method some of the medium will be *swallowed but this is without adverse effects* To allow for this loss some 15 millilitres should be instilled for each side

Posturing of the Patient During Bronchography

After injection of the contrast medium by any of these methods it is necessary to posture the patient in order to fill all the bronchi to the various lobes and segments

The right side

The following is a suggested routine for filling the right side When the medium is injected the patient should be reclining with head raised and inclined 30 degrees towards the right side After about 10 seconds *during which time the medium descends to the right main bronchus the patient* (still inclined to the right) should lean forwards 30 degrees past the vertical position to fill the anterior basal and middle lobe branches then backwards 30 degrees to fill the lateral and posterior basal and apical lower lobe branches *He then lies on his right side* to fill the axillary branches

In order to get good filling of the upper lobe especially if an intratracheal catheter is being used it is helpful to inject the contrast medium in two parts starting with 10 millilitres and after the lower

lobe has been filled injecting a further 5 millilitres with the patient still lying on his side Whether this is done or only a single injection is made the patient is then turned to lie in the prone oblique and finally the supine oblique positions to fill respectively the anterior apical and posterior branches of the upper lobe

When all the major bronchi of the right side have thus been filled the patient should lie on his right side on the cassette and a right lateral view radiograph of the chest should be taken He then turns and lies prone or supine and an anterior (or posterior) view is taken

Sometimes an additional right anterior oblique view is indicated finally an anterior view may be taken with the patient standing up for the purpose of showing an oil level in any partly filled cystic bronchiectasis as well as ensuring satisfactory distal filling of the basal bronchi

Timing of postural manoeuvres

The timing of the posturing will depend on the speed with which the contrast medium runs down At average room temperature it should reach the main bronchus about 30 seconds after it has been instilled into a nostril or less if it has been injected down a needle through the crico thyroid membrane

The various postural manoeuvres generally occupy 1–2 minutes after which time the more proximal bronchi should all be filled To ensure that one radiograph at least will show more distal filling a delayed radiograph taken about 15 minutes later is often valuable especially if the distal penetration of the contrast medium does not seem adequate in the first series of radiographs

Check up on filling

Directly the first series of radiographs has been taken a rapid fluoroscopic survey may be made to ensure that all the bronchi are adequately filled Alternatively the radiographs should be inspected as soon as they are cleared by the fixing solution and a check up made on the filling and any blurring due to movement or faults of exposure If any bronchopulmonary segments are seen to be incompletely outlined and there is no positive evidence that this is due to bronchostenosis it may be necessary to inject more of the medium and make further attempts to fill these segments by suitable posturing

The left side

If filling of the right side was satisfactory the examination of the left side can be undertaken at the same sitting For this purpose a further 10–15 millilitres of the contrast medium is introduced into the trachea and the postural movements repeated this time with the patient inclined to the left The first radiograph will be a left posterior oblique view at about 45 degrees rotation followed by an anterior (or posterior) view If the left side only is filled an additional left lateral view should be taken The adequacy of the filling should be checked as described above

X Ray Technique

The x ray technique will in general be the responsibility of the radiologist It is desirable that the x ray tube column will rise high enough to give a tube film distance of not less than 4 feet for the films taken lying down The radiographs taken standing up should be taken at a tube film distance of 5 or 6 feet

The exposure will be roughly of the same magnitude as that used for the plain radiographs but 5–7 kVp higher The film should be exposed during suspended inspiration of only moderate depth Full inspiration is unnecessary and likely to precipitate a bout of coughing The patient should therefore be asked to take a breath in gently and then to hold it in

In a case showing only slight dilatation in one part it may be useful to take a pair of radiographs one in rather full inspiration the other in full expiration so that any excessive calibre changes with respiration can be seen

Drainage After Bronchography

After the bronchography much of the contrast medium especially if iodized oil was used can be drained by posturing the patient and asking him to cough it up The patient may sit up and cough in order to empty the upper lobes and should then lie prone on a bed the foot end of which is raised and cough in this position to drain the lower lobes

INDICATIONS FOR BRONCHOGRAPHY

Although bronchography is relatively safe and not very unpleasant for the patient it should not be undertaken without a definite objective and once this is defined every effort should be made to obtain the requisite information

Adequate recent plain radiographs and when necessary tomographs should be available and in many cases bronchoscopy should precede bronchography even though this may entail transfer of the patient to a special unit

In the majority of cases of bronchiectasis there will be some evidence of its presence in the plain radiographs or tomograms Provided this evidence is reasonably clear bronchography is not justified purely for diagnosis if owing to age or other factors neither surgery nor postural drainage is under consideration and a knowledge of the exact extent of the lesions is therefore not required

The main indications for bronchography are as follows

For correct x ray diagnosis

(1) To confirm a diagnosis of bronchiectasis if this is suspected clinically but the plain radiographs (and perhaps the tomograms) are normal or if changes are present but these are too slight or not sufficiently characteristic for a diagnosis of bronchiectasis

(2) In cases of unexplained haemoptysis which might be due to bronchiectasis or a neoplasm amenable to treatment but in which no lesion was seen on bronchoscopy or the plain radiographs

(3) To obtain further x ray evidence concerning the possible nature of a lesion visible on the plain radiographs and tomograms

Exact anatomical localization of lesion

(1) To define the exact anatomical extent and segmental distribution of the bronchiectasis of which there is some definite evidence on the plain radiographs or tomograms especially if surgical treatment is under consideration or if accurate postural drainage is likely to be an important feature of medical treatment

(2) To define the exact segmental localization and bronchial anatomy in relation to a lesi[illegible] ible in the plain radiographs if this information cannot be obtained from the lateral view tomo[illegible] nd surgical treatment is under consideration

For research purposes

Bronchograms may be indicated for the purpose of research provided that the researc[illegible] t is well planned and executed for example to see the extent and type of bronchial abnormaliti[illegible] nic bronchitis or to see the extent of associated bronchiectases in some cases of tuberculosis

THE NORMAL BRONCHOGRAM

Figures 141 and 142 are diagrammatic tracings from normal bronchograms together with the terminology accepted by the Thoracic Society (1950) and approved by an international committee

When studying a bronchogram it is necessary to identify and name all the various segmental branches outlined even if their position is altered by pathological processes or if some are not seen because they are occluded or have been removed

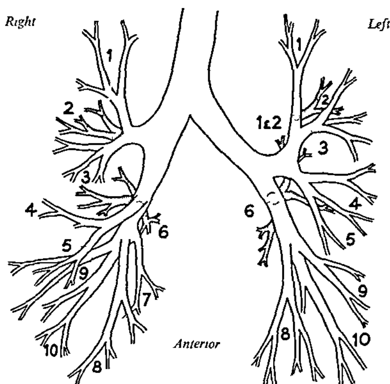
The anterior (or posterior) view should be inspected first and the outline of the trachea noted Then the right or left main bronchi should be traced down to their first divisions into the upper and lower lobe branches Absence of either an upper or lower lobe will thus be noted

The branches of the anterior and posterior segments of the upper lobe in particular and those of the middle and lower lobe are usually partly superimposed in an anterior view and can only be properly identified in the lateral or oblique view

RIGHT BRONCHOGRAM

Starting with the bronchogram taken after filling the right side only inspection of the anterior view will reveal the presence or absence of an upper and of a lower lobe group and any premature filling of the left side which might cause confusion in the lateral view

The right lateral view is then inspected and the origin of the middle lobe bronchus sought If filled it will be the first anterior branch after the 2-centimetre bare area of the intermediate bronchus lying below the uppermost branches which are normally of the upper lobe Its identity is confirmed if it runs almost parallel to the intermediate bronchus before joining it and if the apical lower lobe bronchus (6) can be seen passing directly posteriorly just below its origin



UPPER LOBE

1 Apical bronchus
2 Posterior bronchus
3 Anterior bronchus

Right MIDDLE LOBE	*Left* LINGULA
4 Lateral bronchus	4 Superior bronchus
5 Medial bronchus	5 Inferior bronchus

LOWER LOBE

6 Apical bronchus	6 Apical bronchus
7 Medial basal (cardiac)	8 Anterior basal bronchus
8 Anterior basal bronchus	9 Lateral basal bronchus
9 Lateral basal bronchus	10 Posterior basal bronchus
10 Posterior basal bronchus	

Figs 141 and 142 —Diagram illustrating the broncho-pulmonary nomenclature approved by the Thoracic Society (*Reproduced by permission of the Editors of "Thorax"*)

If the middle and apical lower lobe bronchi are thus confidently identified, then the three upper lobe bronchi (apical (1) posterior (2) and anterior (3)) should be seen above and the three basal bronchi (8 9 10) below

Although the cardiac branch (7) is quite large it is often inconspicuous and distinguished with difficulty from the anterior basal branch (8) It is perhaps more easily identified in the anterior than the lateral view and lies medially

The early lateral divisions of the middle lobe (4) tend to lie below the medial division (5) in a lateral view This relationship will alter if there is shrinkage of one segment and identification of these two branches may then only be possible by reference back to the anterior view

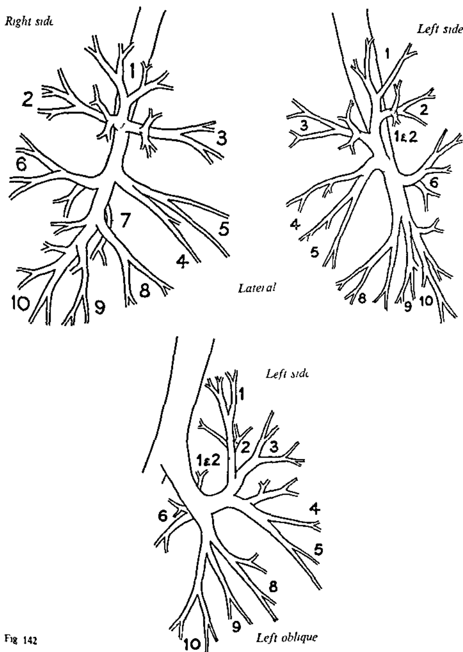


Fig 142

A large branch is often seen arising from the posterior basal bronchus (10) passing directly backwards parallel to and 2 centimetres below the apical lower lobe bronchus (6) This is often known unofficially as the sub-apical bronchus

Left Bronchogram

In the same manner after the left side has been filled careful identification of the lingular bronchus in *the left lateral or left posterior oblique view will make identification of the* other branches much easier The lingular bronchus is the lowest division of the short upper lobe stem It commonly has a large axillary branch passing directly laterally which must not be confused with the anterior bronchus (3) The superior division (4) passes downwards and forwards whilst the inferior division (5) is the most medial branch and is further identified by a particularly even forked division after it has coursed downwards and slightly forwards for 1–2 centimetres

If there is any difficulty in identification of the lingular bronchus identification of the apical lower lobe bronchus (6) may be of some assistance It arises immediately after the origin of the lower lobe stem Care must be taken to separate the lateral division of this from the inferior division of the lin ular bronchus whose path it crosses in the anterior view

Variations of the manner in which the apico posterior (1 2) anterior (3) and lingular bronchi arise from the upper lobe stem or from each other are common (Brock 1954 Boyden 1955) If the lingular bronchus is *identified such variations (or displacements)* rarely cause confusion

PATHOLOGICAL APPEARANCES IN BRONCHOGRAMS

Bronchial Occlusion and Bronchostenosis

Occlusion of a bronchus may be the only visible pathological change in the bronchogram or multiple *occlusions may be seen in addition to dilatations The former may indicate the underlying* disease process the latter are a frequent complication of bronchiectasis particularly when infection is also present

Occlusion of larger bronchi

Occlusion of one of the larger bronchi may be obvious at the first inspection of the bronchogram *or it may only be detected after careful identification of all the filled larger bronchi* For instance the occlusion of the medial division of the middle lobe shown in Figs 83 and 84 was not detected until all the other branches were enumerated and the missing one thus identified

It may not be easy to decide whether the occlusion is organic due to a temporary mucous plug or to a technical fault Any irregularity of the contrast medium at the site of the block or a lung opacity distal to it (Fig 143) perhaps only visible on tomograms will indicate an organic cause

Proximal bronchostenosis

Bronchostenosis without complete occlusion at the proximal end of a bronchiectasis may easily pass undetected if attention is concentrated on the distal and often obviously dilated bronchi The whole of the filled bronchial tree should be carefully examined and such a filling defect will then not be so easily overlooked

The cause of the filling defect is best discovered by means of bronchoscopy provided the lesion is within range If not the shape of the stenosis on the radiograph may give a clue An irregular rat tail narrowing is often seen with a carcinoma a smoother narrowing with fibrosis following tuberculous endobronchitis A small local filling defect however may be caused by a mass of tuberculous granulation tissue which may be indistinguishable on the radiograph from the filling defect caused by a small carcinoma

An air bubble or mucous plug may simulate either of these conditions but is unlikely to maintain its position unchanged in all the radiographs of the series especially *if a delayed radiograph is taken* 10 15 minutes after the first series

A temporary local bronchial spasm may be difficult to distinguish from an organic narrowing It is unlikely to occur except in a patient known to suffer from chronic bronchitis or asthma and tends to appear as a smooth concentric narrowing without gross distal changes

Occlusion of smaller distal bronchi

Quite different from these proximal changes which are generally the result of the lesion causing the bronchiectasis are the more distal occlusions and bronchostenoses invariably present in the actual

region of the dilatations The occlusions are readily detected by counting the number of branches arising after the origin of the segmental bronchus In a normal bronchogram about 16 or more branches can be counted along a bronchial pathway whilst in a region with bronchiectasis there will be many fewer and it is not unusual for there to be less than 4 branches These occlusions of the smaller branches are readily confirmed in studies of specimens after resection

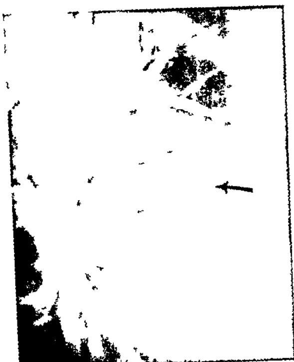


Fig 143 —Occlusion of the superior division of the lingula (marked by arrow) Left posterior oblique view bronchogram The small shadow below the tip of the arrow is an intrapulmonary calcification suggesting that the occlusion is due to a tuberculous lesion Female aged 33 years Small haemoptyses Tubercle bacilli in sputum No proof yet of nature of lesion



Fig 144 —Tubular bronchiectasis of the left [illegible] lingula Anterior view bronchogram N[illegible] filling of all the smaller branches and th[illegible] dilated larger ones which terminate half w[illegible] the diaphragm Male aged 14 years with [illegible] and haemoptyses Specimen showed much [illegible] surrounding alveolar tissue

Bronchostenosis in area of dilatation

Areas of narrowing (bronchostenoses) are also frequently seen between areas of dilatation From this bronchographic observation as well as from morbid anatomical studies and from the histological findings of inflammatory changes in the bronchial walls and of abnormalities in the surrounding lung it is apparent that the word bronchiectasis does not truly describe the clinico pathological state so designated bronchial dilatation being only one of a variety of changes found in it

Occlusion at point of termination of dilatation

Occlusion of the distal ends of the dilated bronchi in bronchiectasis often make these shorter than normal and they are then seen in the bronchograms to terminate some distance above the diaphragm with rounded or clubbed ends (Fig 144)

This appearance must not be confused with the so called broken bough appearance in which normal sized bronchi end abruptly because the medium does not penetrate far enough distally This broken bough appearance is also seen in bronchi which look wider than normal but in which the walls are nevertheless still parallel and is also sometimes seen in normal or rather wide bronchi which are crowded together as a result of lobar shrinkage In either case the fact that fewer branch bronchi are outlined contributes to the appearance of widening The condition is commonly seen in children though also in adults and is probably either a manifestation of chronic bronchitis with excessive mucus

secretion or of the mechanical results of atelectasis of the surrounding alveoli and is not a manifestation of the clinical state of bronchiectasis

Bronchial Dilatation

Dilatation of the bronchi in bronchiectasis may be generalized or confined to a single segment or single bronchus The dilatations may be more or less tubular fusiform (spindle shaped) or saccular (cystic)

Tubular dilatation

Tubular dilatation (Fig 144) is the most common form observed and is usually seen when the larger bronchi are dilated It is often the late result of a lobar or segmental bronchostenosis brought on by a neoplasm a foreign body or by pressure from an enlarged gland or local tuberculous ulceration In such cases investigation and treatment of the causative lesion may be more important than the secondary bronchiectasis

In many cases however the original obstructive cause is no longer present by the time the patient comes for investigation and the residual bronchiectasis is the predominant lesion requiring treatment In some cases the bronchial dilatations are associated with very little reduction in lung volume In others there is gross shrinkage of the affected lobe and the dilated bronchi are seen to be crowded together the plain radiograph showing an opacity similar to that found in obstructive atelectasis

It is sometimes suggested that tubular bronchiectasis in an airless shrunken lobe may be reversible This may be the case in a temporary stenosis and atelectasis such as is found in primary tuberculosis when the bronchi in the airless lobe which are undoubtedly abnormally wide may return to normal if the lobe later re-expands Such a temporary atelectasis without distal infection is usually a radiographic finding only and in spite of the dilatations seen on the bronchograms there is no clinical picture of bronchiectasis The dilatations may in fact represent a physiological widening resulting from the peculiar pressure changes in the surrounding airless lung without permanent changes in the bronchial wall

Should infection occur and the clinical picture then become that of bronchiectasis it is doubtful if the bronchi will in fact return to normal since many of the smaller branches will become permanently occluded and the bronchiectasis is then irreversible

Fusiform dilatation

Fusiform dilatations (Fig 145) are frequently observed following an aspiration pneumonia or a febrile incident with eosinophilia in an asthmatic bronchitic They are apparently due to a local destructive lesion eroding or weakening the bronchial wall locally and are often combined with short lengths of tubular bronchiectasis They may also be found associated with long standing tuberculous foci or may be evidence of a local tuberculous endobronchitis

Saccular dilatation

Saccular or cystic dilatations (Fig 146) are seen particularly when small proximally situated branch bronchi or small distal bronchi are dilated

Fine ring shadows may be seen on the plain radiograph but sometimes widespread 1–2-centimetre saccular dilatations are found unexpectedly when there are minimal changes on the plain x ray In some cases the dilatations may be developmental but a similar radiographic appearance may be found following an inflammatory episode such as a staphylococcal pneumonia In some cases saccular tubular and fusiform dilatations co exist in the same affected lobe

Another form of cystic dilatation is seen when a whole lobe or segment is more or less destroyed and occupied by large cystic bronchiectatic spaces these will be formed for the most part by gross dilatations of the larger bronchi

CLASSIFICATION OF BRONCHIECTASIS

The shapes of the dilatations

It is possible to classify the shapes of dilatations shown in the bronchograms in the following manner

1 Tubular (affecting larger bronchi)	Normal spacing / Crowding with lung shrinkage	Proximal bronchostenosis cause still present / No cause seen now
2. Fusiform		Frequently end result of local inflammatory episode
3 Saccular (cystic)	Small r bronchi affected	Possibly developmental
	Gross destruction in larger bronchi	Acquired post inflammatory



Fig 145 —Fusiform bronchiectasis of the left upper lobe Male aged 33 years with asthmatic bronchitis Incidents of fever and eosinophilia (during one incident W B C 12 000 with 16 per cent eosinophils) and shadows in the lung on plain radiograph This posterior oblique view bronchogram is of the segment in which one such shadow was seen



Fig 146 —Saccular bronchiectasis in the apical segment of the right lower lobe Right lateral bronchogram Male aged 46 years Twelve years cough and a little sputum one year ago pneumonia developed and much more sputum One haemoptysis Note the occlusion of the bronchi beyond the dilatations

A classification of this sort however does not sufficiently take into account aetiological factors such as whether the infection is with tubercle bacilli or other organisms or what is the morbid histological state of the bronchial walls and surrounding lung

Its value is further diminished by the fact that there is no close relation between these radiographic appearances and the clinical picture Extensive bilateral cystic bronchiectasis may be present with insignificant symptoms whilst the bronchi in a single segment or a single diseased bronchus exhibiting any of the above mentioned shapes of dilatation may be a source of much cough and foul sputum or of repeated severe haemoptyses

The extent of the lesion

A more useful grouping perhaps would be one based on the exact anatomical extent of the lesions which can be accurately judged from bronchograms rather than on the shape of the dilatations This

combined with the clinical picture could be tabulated under types of treatment indicated (provided there is no progressive local bronchostenotic cause such as a neoplasm still present) as shown in Table 1

TABLE 1

Treatment	*Bronchogram*	*Clinical picture*
No local treatment indicated	Lesions too widespread or slight	Symptoms absent or slight
Possible need for postural drainage or chemotherapy	Extent of lesion contra indicates resection	Symptoms present Clinical state contra indicates resection
Consideration of resection of affected area	Lesion localized	Clinical state satisfactory

Associated lung changes in the plain radiograph

Any detailed classification could usefully include associated changes seen in the plain radiograph

Atelectasis

The presence of the shadow of an airless shrunken lobe in some cases has already been referred to above If the shadow persists and there is no longer bronchostenosis the change is usually irreversible

Inflammatory changes

Sometimes small areas of ill defined clouding are seen between the tubular or honeycomb shadows indicating inflammatory changes in the surrounding lung parenchyma If such shadows persist for many months they would suggest irreversible lung damage

Hypertranslucency

Another change sometimes seen between the tubular shadows is small areas of hypertranslucency with absence of vessel shadows These indicate irreversible localized emphysematous or bullous areas and are found when there is much lung damage and interference with aeration in nearby parts from occluded smaller bronchi

Changes due to underlying cause

Finally local lung changes producing local associated bronchiectasis may dominate the picture on the plain radiograph For instance the massive opacity of a chronic suppurative pneumonia with or without lung abscesses is usually accompanied by bronchiectasis in the affected area Again in most cases of fibro cavernous tuberculosis some dilated bronchi will be seen in the affected area if a bronchogram is performed

In many cases of primary tuberculosis following the disappearance of a massive lobar opacity (with or without shrinkage) a bronchogram will show a residue of dilated bronchi even if the plain radiograph is by then normal or almost normal In an upper lobe such a lesion is usually clinically silent

LOCALIZED AND PERIPHERAL CHANGES IN CALIBRE OF AIR PASSAGES

Excessive calibre changes on respiration

The larger bronchi in a normal person appear rather wider in a bronchogram taken in full suspended inspiration than one in expiration and in some subjects a local exaggeration of this phenomenon is seen in one or two branches only It is usually assumed that bronchograms are taken in inspiration but owing to the patient s fear of coughing general distress or perhaps because he is too young to co operate or is under a general anaesthetic this is not always the case If therefore minimal dilatation is suspected it is worth while trying to obtain one radiograph in deep suspended inspiration and one in expiration

Excessive local calibre change indicates local damage either to the bronchial wall or to the surrounding lung parenchyma and is seen in a few cases of chronic bronchitis when it presumably indicates a past inflammatory episode with local complications

When comparing bronchograms taken on different occasions care must be taken to ensure that any apparent improvement seen is not an artefact resulting from the radiographs being taken in different phases of respiration

Small projections from the wall of the trachea

In elderly subjects the bronchograms may show small projections or diverticula from the lower tracheal wall or the wall of the left main bronchus (Fig 147) These do in fact represent diverticula or pouchings between the bands of muscles which are attached to the posterior ends of the C shaped cartilages Not to be confused with these true diverticula is the corrugated appearance seen with advancing age when there is a tendency to folding of the softer tissues between the more rigid cartilages In a lateral view this folding will be seen to occur only anteriorly



Fig 14 —Diverticula from the left main bronchus (marked by black arrow) and corrugations opposite Left posterior oblique view bronchogram White arrow points to projections of the contrast medium from the under surface of the upper lobe stem due to filling of dilated mucous gland

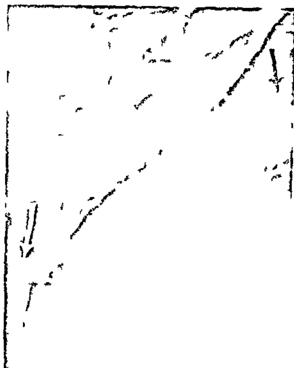


Fig 148 —Circular dilatation at the end of a small bronchus (pooling) opposite black arrow White arrow point t dilatation with projections (spike appearance) Passing proximally an irregular lump of Lipiodol is seen (wattle or mimosa blossom appearance) and above this another pool Male aged 49 years Chronic bronchitis

Small projections from the walls of the larger bronchi

Quite different from the diverticula or foldings are similar projections of the contrast medium commonly seen in patients with bronchiectasis or chronic bronchitis in the region of the segmental bronchi particularly from the inferior surface of the left upper lobe stem the lingular (Fig 147) and the right middle lobe bronchi Exact histological identification of these radiological shadows has been possible after resection in some cases and there is no doubt that these projections represent the contrast medium in dilated mucous gland ducts and are an expression of the excessive secretion of mucus in chronic bronchitis and in some cases of more distally situated localized bronchiectasis

Peripheral non filling

More difficult to interpret are bronchograms in which normal peripheral filling is seen in some areas but no peripheral filling occurs in others although there is plenty of the opaque medium more proximally

It probably represents an abnormality in most cases though whether it is caused by occlusion of the smaller bronchioles by organic disease obstruction by a local excess of mucus a local interference with the normal indrawing of air and contrast medium or a technical fault cannot always be determined This change appears to be more common in patients with chronic cough and mucoid sputum than in subjects with no symptoms but this may be largely because bronchograms are rarely done in normal persons

Peripheral dilatation

Another change frequently seen in bronchograms performed on chronic bronchitics is dilatation of the very small terminal branches resulting in a 2–3 millimetre circular shadow on the end of a small bronchiole instead of the normal ending Such a small homogeneous circular shadow (Fig 148) is sometimes described as peripheral pooling In some cases the shadow has a more irregular clumped appearance simulating a wattle or mimosa blossom (Fig 148) In either case the contrast medium outlines a dilated peripheral bronchiole

Another appearance sometimes seen is a 1 millimetre line or a wider 1–2 millimetre oval shadow with small spikes radiating from it (Fig 148) This again is caused by dilatation and sometimes fibrosis of a peripheral bronchiole

The cause of all these appearances in bronchograms has been verified by careful correlation of the radiographic shadow with the histological sections (Reid 1955)

Distortion of the peripheral bronchi

Distortion of the course of the terminal bronchioles may be observed if they are displaced by bullae or peripheral lung cysts Local displacements will also be caused by any space occupying intra pulmonary lesion or pleural effusion but they will rarely aid the diagnosis

Chronic bronchitis

Enlarged mucous glands the appearance of pooling and spikes distortion by bullae and areas of non filling are usually associated with the clinical state of chronic bronchitis A local excessive calibre change of a bronchus may also be seen in this condition and is often associated with one or more of the other changes If however the calibre change is the only radiographic abnormality its significance must depend on the clinical picture which will indicate whether it is a dilatation associated with chronic bronchitis or a localized bronchiectasis There is no evidence that such a calibre change is progressive and a precursor of clinical bronchiectasis In a few cases where the clinical picture is solely that of chronic bronchitis a bronchogram unexpectedly reveals an area of gross bronchiectasis which again underlines the necessity for a clinical rather than a radiological diagnosis in these conditions

THE BRONCHIAL ANATOMY AS AN AID TO LOCALIZATION OF LESION

Because the bronchial anatomy can be clearly demonstrated on a bronchogram the relation of any abnormal shadow to a particular bronchus can be shown and therefore its exact lobar or segmental distribution or position can be determined

It may be useful to do a tomogram or simultaneous multisection tomograms of the outlined bronchi if the shadow is small and difficult to see in plain bronchograms

ABNORMALITIES OF THE BRONCHIAL ANATOMY

Small variations in the manner in which the bronchi divide are common and are easily recognized in bronchograms Such information may be of value to the surgeon in the execution of a segmental resection

Sometimes the right upper lobe stem or a segmental branch to the upper lobe comes directly off the trachea The recognition of this abnormality may be of importance The bronchi may otherwise be normal or may show a deficiency in development with some dilatation Whenever such a variation is present or when the origin of one of the other lobar or segmental bronchi is displaced it is still possible to identify all the normal segmental divisions

In agenesis of the lung the changes are more severe and not only is the lung very small but it is no longer possible to identify all the segments This feature will serve to distinguish the condition from an acquired bronchiectasis with lung shrinkage In agenesis the shape of the bronchi is also abnormal and they may be thin long and poorly developed (Fig 149) or they may be short and end with a gloved finger type of dilatation

CHAPTER 10

TOMOGRAPHY

A DETAILED list giving all the indications for tomography in chest diseases would be very long. The following abbreviated list is based on cases within the author's experience in which tomograms have provided evidence helpful to the clinician in choosing the correct treatment. There is no doubt that other indications will arise from time to time whenever the evidence of the plain radiograph is inconclusive.

(1) Demonstration or exclusion of a pulmonary cavity; (2) extent and exact segmental localization of lesion; (3) further evidence towards the diagnosis of an abnormal shadow; (4) to supplement the plain lateral view radiograph; (5) demonstration of the lumen of the trachea and larger bronchi; (6) demonstration or exclusion of enlarged hilar glands; (7) demonstration of the main vessels in the hilar regions or lungs; (8) demonstration of calcifications in the heart valves; (9) extent and possible nature of abnormal mediastinal shadows; (10) additional views in suspected lesions of the bones of the thorax.

THE DEMONSTRATION OR EXCLUSION OF A PULMONARY CAVITY

THE INDICATIONS

Tuberculous cavity and lung abscess

The demonstration or exclusion of a cavity by tomography is particularly indicated in tuberculosis and many other types of lesion when an abnormal shadow is seen but there is doubt after inspection of the plain radiographs whether a cavity is present or not. It is particularly important if tubercle bacilli have been found in the sputum. It may also be important even if this test is negative [illegible] the demonstration of a cavity may itself be an indication for a more thorough search for the [illegible] which may then be found.

If tubercle bacilli are found and no abnormal shadows are seen in the plain radiograph [illegible] lateral view, apical view and fluoroscopy), tomograms of the regions behind the hila [illegible] tomograms of the lower half of the lungs may be indicated, since these regions might [illegible] other shadows in the plain radiographs.

If a cavity has once been seen in a case of tuberculosis or lung abscess, but is no longer [illegible] plain radiographs, tomography may be indicated to see whether it has closed or not.

Bronchiectasis

Using the expression "cavity" in the sense of any abnormal intrapulmonary air space, tomography is indicated to prove or exclude gross bronchiectasis in cases where tubular or honeycomb shadowing is suspected on the plain radiographs but it is indistinct or obscured by overlying and surrounding shadows.

Cystic dilatations usually stand out very clearly (Fig. 150), while tubular dilatations can be seen in most cases, especially if a view can be taken with them more or less parallel to the film. The method is of course not as reliable or informative as bronchography, but if the objective is only diagnosis and not to discover the extent and character of the dilatation, the demonstration of any dilatation by tomography may make bronchography unnecessary. This is particularly true in cases of bronchiectasis where surgery is not contemplated.

The demonstration of bronchiectasis near a solid tuberculous focus by tomography may also make bronchography unnecessary and might favour resection rather than some other method of treatment.

Bullae

Bullae and bullous air spaces may also be demonstrated clearly (Fig. 124), even when they are only suspected on the plain radiographs, and it is sometimes useful to show their site and extent.

Preliminary Inspection of the Tomograms

A preliminary inspection of the tomograms to ensure that the technique has been adequate is an important factor which contributes largely to the reliability of the method, particularly in the diagnosis of a pulmonary cavity.

Order of films for viewing

The films should first be arranged on the viewing box in their correct layer order according to the numbers marked on each film. The order should then be checked by observation of some obvious landmark such as the ribs. If in a posterior view series the visible part of the ribs does not become more anterior as the layers progress, the films may have been wrongly marked or an error may have been made in the setting of the layer selector. Alternatively and more commonly the patient may have moved in the interval between two exposures, or his respiration may have been of a different depth. If a discrepancy is observed and cannot be corrected with certainty, it may be advisable to repeat the series.



Fig. 149.—Agenesis of the right lung. Posterior view bronchogram. The abnormal shape and distribution of the bronchi *in the small right lung is clearly seen. There is no distal* dilatation of the bronchi. The left side shows a normal pattern.



Fig. 150.—Cystic bronchiectasis of the right lung (tomogram). Arrow points to one of the well defined ring shadows. They *were inconspicuous in the plain radiograph but filled with* Lipiodol on bronchography. Male aged 40 years. Ten years cough and sputum.

Checking up on the area covered

Assuming that the order of the layers appears to be satisfactory, it is then necessary to make sure that the correct area has been covered. Inspection of the previous plain radiographs or tomographs and the clinical picture will have given a clear idea of the object of the examination, and it will be possible to judge whether the series includes a sufficiently large area. It is important to remember that owing to the relatively short tube film distance used, the shadow of a lesion near the edge of the tomogram will be some distance from the centre of the x ray beam and may therefore be considerably displaced from the position it occupied in the plain radiograph. Care should therefore be taken to see that the suspected region is in fact on the tomogram and not displaced beyond the film.

The range in depth of the layers

The range of the layers should then be noted to ensure that it extends sufficiently backwards or forwards or in the case of a lateral view tomogram medially and laterally It is safest to judge this by the visible anatomical landmarks rather than by the depths recorded on the films In a posterior view one layer at least should show the posterior parts of the ribs quite clearly since only then will it be certain that the whole of the posterior part of the lung has been included in the series If abnormal shadows are visible in the plain radiographs care must be taken to identify these in the tomograms Similarly if previous tomograms are available any vessels calcifications or other landmarks in the old series should be identified in the new to ensure that comparable layers have been taken Many errors have resulted from a failure to take these precautions

In comparative tomograms it is particularly important not to place too much reliance on the layer depth identification numbers marked on the films Apart from being subject to a radiographer s error these numbers are often misleading because of differences of calibration on different sets In some departments the depths are measured from the table top in others from the film which is 2–4-centimetres lower Even if the film layer depths are correctly understood the abnormal shadow may really lie at a different depth from the table top in the two series either because the patient is lying in a different position if for instance there is an additional pillow under his head or because the lesion has changed its position in the chest as a result of other intrathoracic pathological conditions such as nearby scarring or bronchostenosis or as a result of a pneumothorax or other therapeutic procedure

Spacing of layers

The spacing between the tomographic layers should not in general exceed 1 centimetre This is the maximum thickness in which poorly contrasted shadows such as those of small cavities or normal vessels are clearly visible Beyond this limit such shadows are blurred out by diffusion if an arc of swing of 25 degrees or more is used

DIAGNOSIS OF THE RING SHADOW

Identifying the ring

A clearly-defined ring shadow seen for the first time in a series of tomograms is not [illegible] use difficulties of interpretation (Fig 161) Nor is a less well defined shadow which has [illegible] on previous plain radiographs or tomograms On the other hand in a great many cas[illegible] appearance giving the impression of a ring shadow is seen for the first time on the tom[illegible] circumstances particular care should be taken to confirm its identity and avoid a fals[illegible]

The wall of the supposed ring should first be examined If any part of it is seen to [illegible] vessel shadow this part should be considered to be a vessel and not a contribution to th[illegible] Similarly if the apparent wall is of uneven thickness close inspection may reveal that some of it [illegible] by a separate nearby circular shadow An indrawn tag of thickened pleura may also simulate th[illegible] lateral wall or roof of a cavity If all such irrelevant shadows are removed in imagination what is left may provide no case for the diagnosis of a cavity On the other hand a complete ring shadow may still be present even after the nearby irrelevant shadows have been ignored

In a case of doubt valuable and decisive evidence may be obtained from lateral view tomograms in addition to the posterior ones or from some additional intermediate layers giving a ½-centimetre spacing

A ring shadow still seen after such stringent analysis and careful technique will nearly always turn out to be a cavity if the piece of lung becomes available for pathological investigation

Identification in serial tomograms as the cavity alters

A cavity which has been demonstrated on previous radiographs or tomograms may become much less distinct because it decreases in size or becomes filled with secretions or because the contrast between its wall and the surrounding lung decreases as treatment progresses Because of the exact anatomical localization which can be achieved by tomography when vessels or other shadows in the proximity of the cavity can be identified in both series it is possible to be certain of the continued existence of such a cavity in spite of the alterations in its appearance

Differential diagnosis

It may not be possible to distinguish radiologically between the different types of cavity or air containing spaces The cavity for instance may be a distended bronchus (Fig 117) or a bulla (Fig 124) Distinction between a small thin walled tuberculous cavity or a bulla is often difficult A ring shadow particularly at the extreme apex of the lung is more likely to be a tuberculous cavity if the wall is thicker than a hair line (0 5 millimetre) and if there is any evidence of a linear or tubular shadow extending from it towards the hilum It is more likely to be a bulla if the wall is very regular and of hair line thickness (Fig 151) and if there are linear or stellate shadows or a thicker walled ring shadow nearby and if there is a suggestion of vessel atrophy in proximity to it These two conditions however cannot always be distinguished from each other on the tomograms For instance in one patient suffering from tuberculosis the tomograms showed three similar ring shadows in the right upper zone but after resection the specimen showed that one of these was a tuberculous cavity and the other two bullae

Reliability of the method

It is a common experience to see a ring shadow indicating a cavity on a tomogram which either could not be seen at all or could not be seen with any certainty on the plain radiographs If such evidence can be shown to be reliable the importance of tomography as a method of investigation needs no underlining

With care in the technique and interpretation it is possible to find that the diagnosis or exclusion of an air containing space is confirmed in over 90 per cent of cases when the resection specimen is examined Disagreement between the radiological and pathological findings is sometimes found if the cavity is full or almost full of caseous material

Sometimes no cavity is found on macroscopic examination of the specimen either because the tomograms are not sufficiently recent and the cavity has apparently closed in the interval or because the distortion of vessels thickened pleura or the position of nearby pathological foci have lead to an unavoidable error in interpretation Such errors are few and are rarely of serious consequence to the patient

The objection might be raised that the material available for histological confirmation is highly selective resection being most commonly adopted as a method of treatment if the diagnosis of cavitation is beyond doubt in the cases from which the present conclusions have been drawn however this has not been so since they have included quite a high proportion of non cavitated resected lesions In addition a careful clinical and tomographic follow up of cases not treated by resection has also tended to confirm the high degree of accuracy found in the demonstration or exclusion of cavities by tomography

EXTENT AND EXACT SEGMENTAL LOCALIZATION OF LESION

Extent of Lesion

In many cases of pulmonary tuberculosis tomograms should be taken as soon as it has been decided to undertake treatment By this method additional small foci are frequently seen which are invisible in the plain radiographs

Tomography of both lungs is not indicated as a routine but tomograms should be taken of the lung in the region of any localized group of shadows If the shadows lie in the region above the clavicle posterior view tomograms will suffice if the shadows are lower down however lateral view tomograms may be most useful Lateral view tomograms may also be indicated to prove or exclude the presence of small lesions in some special region such as the apex of the lower lobe in a case with visible lesions in the upper lobe

Correlation of lateral view tomograms with resection specimens shows a very high degree of accuracy of the method in demonstrating or excluding cavities and small solid foci as well as in their segmental localization It is however apparent that a lesion smaller than 0 5 centimetre is usually invisible whilst a somewhat larger lesion may pass undetected in a large patient if it lies at the extreme apex posteriorly overlying the vertebral column or adjacent to the heart shadow In such a case a higher

standard of accuracy will be obtained if the lateral view is supplemented by an oblique view series of the more medial layers opposite the vertebral column Small shadows in the posterior part of the ap x of the left lower lobe may be seen more clearly if they are thrown clear of the shadow of the vertebr l column by rotating the patient until the right shoulder is 10-15 degrees forwards

On the whole there is a tendency to under read the shadows in a lateral view tomogram and it i uncommon to see shadows and not find corresponding pathological foci in the specimen whilst foc seen in the specimen are often not very conspicuous in the tomograms On this account even faint abnormal shadows seen in lateral view tomograms should be given more emphasis than they might have received had they been seen in other views

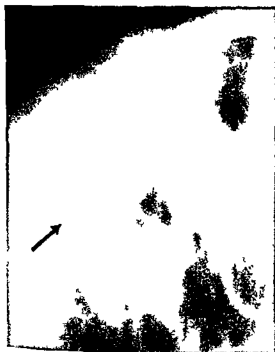


Fig 151 —Two ring shadows in the right lung Posterior view tomogram The ring shadow with the rather thicker wall (opposite arrow) is due to a tuberculous cavity The ring shadow medially and below it with a thinner wall is a bulla

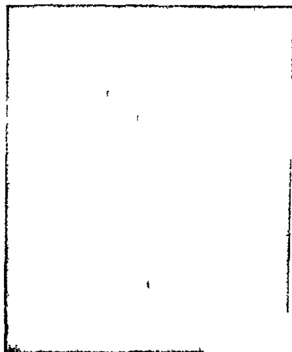


Fig 152 — Two-centimetre tuber ulou foc band like shadow is the essel with s rr t tissue p ssing from the focus to jo n inferi r p Shadow i therefore in the apex of th r ght low r

Exact Segmental Localization of Lesion

The exact segmental localization of a lesion is obviously of great value to the surgeon Using lateral view tomograms the great majority of cavities or solid lesions larger than 0 5 centimetre can be localized to a particular segment with certainty The localization is relatively easy if the fine white hair line of an interlobar fissure can be identified This is commonly so but even if the fissure is invisible or much displaced by lobar shrinkage localization will still be possible by identification of the vessels (Fig 152) or even the segmental bronchus

FURTHER EVIDENCE TOWARDS THE DIAGNOSIS OF AN ABNORMAL SHADOW

The interpretation in terms of morbid histology of almost any shadow seen in the plain radiographs is a hazardous business and in cases where there are no clues from the clinical and pathological findings any additional evidence may be of help In this respect tomograms are often very useful giving as they do further evidence more certainly and at an earlier stage than the plain radiograph or early clinical investigation

They will show any additional satellite shadows which may be present whether a shadow is related to nearby vessels and bronchi the presence or absence of cavitation any calcium or bony deposits within the shadow or nearby any adjacent pleural thickening any rib involvement or any associated glandular enlargements

Satellite shadows are uncommon in a small peripheral neoplasm and common near a tuberculous focus The wide abnormal vessels leading to and from the shadow of an arterio venous aneurysm are characteristic and they may be so clear on the tomogram that angiocardiography is not necessary for diagnosis The presence of air containing bronchi within a massive shadow will prove that the shadow is pulmonary and not pleural (Fig 62) Linear shadows suggesting bronchi vessels or peribronchial fibrosis are seen between the shadow and the hilum much more commonly in an inflammatory lesion than in a neoplasm

Cavitation does not usually occur in a small neoplasm but is common in small tuberculous foci The calcium in tuberculous foci tends to be distributed either in a patchy manner or in concentric rings whilst in a hamartoma it is in one small almost central spot (Fig 99) or forms a large deep amorphous mass

Adjacent pleural thickening may by its shape and position indicate that the shadow is pleural as in an interlobar effusion or that it has a pulmonary and pleural component If the shadow is near the surface rib changes such as erosion or periosteal new bone may be seen in a tomogram before they are visible in the plain radiograph The presence of hilar glandular enlargement in association with small circular shadows will suggest sarcoidosis rather than ordinary tuberculosis

TO SUPPLEMENT THE PLAIN LATERAL-VIEW RADIOGRAPH

The great value of the plain lateral view radiograph in many cases is beyond dispute but its limitations are not always appreciated Because of the large number of superimposed normal shadows the difficulties of interpretation are great even when satisfactory films are available and almost insuperable when the films are of poor quality as is too often the case A lateral view series of tomograms will usually show an individual shadow so much more clearly that it is often indicated to supplement the plain lateral view

Figs 77 and 78 illustrate how much more clearly the spindle shadow of an atelectatic middle lobe is seen in the tomogram than in the plain radiograph Even a large homogeneous 2–3 centimetre shadow situated higher up may be equally difficult to see in the plain radiograph because of the overlying shadows of the shoulder girdle vertebrae or aorta it will be seen quite clearly however when these structures are blurred out by diffusion in a tomogram (Figs 155 and 156)

The presence of abnormal shadows on the contralateral side such as may result from an effusion an old thoracoplasty or other surgical procedure a pneumothorax or even much contralateral lung disease will also result in superimposed and confusing shadows in the plain lateral view Lateral view tomograms may be the only satisfactory method of showing the exact position of a lesion in such circumstances

DEMONSTRATION OF THE LUMEN OF THE TRACHEA AND LARGER BRONCHI

The trachea and proximal bronchi are as a general rule best inspected by bronchoscopy but in certain circumstances the demonstration of the tracheal and bronchial air translucencies on a tomogram is a useful supplement and occasionally a substitute for this method of investigation

Tomograms may precede bronchoscopy in some cases in which tubercle bacilli have been found in the sputum but no lesion has been seen in the plain radiographs of the lungs The demonstration of a narrow area in the translucency of the trachea or a main bronchus will suggest the possibility of a tuberculous bronchitis and such a finding may accelerate or delay bronchoscopy

Tomograms may follow bronchoscopy in some cases in which the lower limits of the affected area have not been seen because of the stenosis Fig 153 is a supplementary tomogram of this kind It shows the whole length of the stricture with the normal part of the tracheal translucency above and below it proves the stricture to be related to a nearby calcified gland and obviously short and thus indicates that surgical reconstruction would not be too formidable This was in fact undertaken

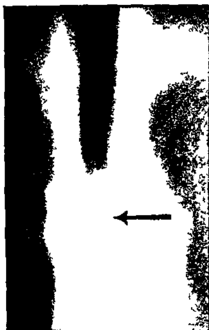


Fig 153—Stenosis of lower end of trachea (tomogram) Stricture with shadow of a calcified gland just to the right is seen opposite arrow Male aged 36 years Five years increasing dyspnoea Admitted as an emergency Upper limit of stricture visible on bronchoscopy Plastic repair Post-operative tomogram showed good airway

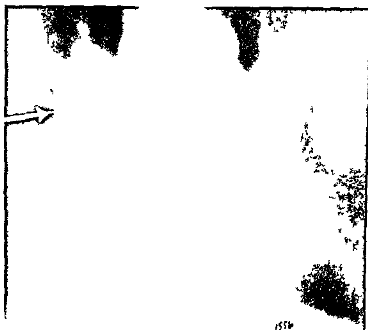


Fig 154—Enlarged hilar gland (tomogram) Arrow points to the lateral convex border of the abnormal glandular shadow which is marked above by the translucency of the upper lobe bronchus and medially by that of the intermediate bronchus Branches of the pulmonary artery are seen above it and branches of the pulmonary vein just below it There are enlarged glands around the left lobar bronchial translucencies Male aged years Sarcoidosis



Fig 155—Carcinoma apical segment of the left lower lobe Plain lateral view Indistinct opacity superimposed on the shadow of inferior part of the scapulae Anterior view normal though suggestion of slight enlargement of left hilum



Fig 156—Same case (left lateral view tomogram) The shadow of the neoplasm can now be clearly seen Male aged 57 years Recently a small haemoptysis Bronchoscopy and biopsy revealed a poorly-differentiated bronchial carcinoma

with complete relief of the near strangulation The clinical picture and post operative tomograms showed a good airway and made further bronchoscopy unnecessary

If a patient is too old or ill for radical treatment the demonstration of a bronchostenosis on a tomogram may be a substitute for bronchoscopy The tomogram will show the relation of the narrowing to any nearby opacity but will not give any indication of the histology of the lesion

Finally bronchoscopy may have been performed with a negative result and yet a tumour may still be suspected This is apt to occur with a small neoplasm causing narrowing of a segmental upper lobe bronchus or of the main middle lobe stem 1–2 centimetres beyond its origin and in such a case tomograms may demonstrate an area of narrowing

Accuracy of the Method

The left and right main bronchus the right upper lobe bronchus and the intermediate bronchus can nearly always be clearly shown in posterior view tomograms but distal to these bronchostenosis must be diagnosed with caution The x ray diagnosis will be fairly certain if the narrowing or occlusion is related to an adjacent abnormal shadow or if the narrowing is irregular or tapering If an apparent narrowing is smooth and rounded or oval it may in reality be caused by the disappearance of the normal bronchial translucency from the clear tomographic layer as the bronchus is rarely parallel to this The continuity may be traced into the next tomographic layer but as the bronchus passes distally it tapers and becomes difficult to see in any case so that inability to visualize it further does not always prove occlusion

In certain regions suspected narrowing can often be confirmed or excluded by tomograms taken in other views The right middle lobe bronchus is seen most clearly in a right posterior oblique view tomogram the left lower lobe bronchus in a left lateral view and the left upper lobe and the proximal parts of its segmental divisions in a left posterior oblique view

In spite of the difficulties and limitations the demonstration of the bronchial air translucencies by tomography is often of great value The method can be supplemented when necessary by bronchography if no lesion has been seen at bronchoscopy

DEMONSTRATION OR EXCLUSION OF ENLARGED HILAR GLANDS

Distinction from Vessel Shadows

The hilar glands when they are normal or only slightly enlarged cannot be seen in the plain radiographs and even when they are considerably enlarged it may not be possible to say whether the resulting abnormal shadow is an enlarged gland or a prominent or enlarged vessel Tomograms are particularly useful for making these distinctions If the enlargement is due to a vessel shadow the tomogram will reveal continuity between it and other unmistakably vascular shadows If it is due to some structure independent of the vessels such as an enlarged lymphatic gland (Fig 154) the shadow may be found to be most conspicuous in a different tomographic layer to that in which the main vessels are most conspicuous and its margins will not taper out here and there into the vessel shadows

The site of the enlargement will also be a factor in the diagnosis Enlarged glands frequently lie between the translucencies of the main upper lobe and lower lobe bronchi and cast a shadow in this situation with a well defined lateral convex margin If in addition the shadow has a well defined inferior margin or lies at a slightly lower level the diagnosis will be even more certain for at this level the vessels cast a continuous shadow down towards the diaphragm

Lateral View Tomograms

A careful inspection of the posterior view tomograms will generally show whether there is an abnormal shadow at all and whether it is vascular or independent of the vessels If distinction between these two causes of an abnormal shadow in this region is difficult lateral view tomograms are indicated These will generally give further evidence especially on the left side where the sweep of the pulmonary artery round the bronchus gives such a characteristic shadow that it is easily identified and where any additional shadows seen close to but separate from it can be recognized as pathological tissue On the right side

enlarged hilar glands tend to be lateral to the vessels in a posterior view and below the main vessel *shadow in a lateral view*

Value of the Method

Bearing the difficulties of interpretation in mind there is no doubt that hilar glandular enlargements *can be detected earlier and with greater certainty in tomograms than in plain radiographs*

If the hilar regions are much obscured by overlying pathological lung shadows as in some cases of sarcoidosis the tomograms may be the only reliable radiographic method of showing or excluding *hilar glandular enlargement*

Tomograms will show the presence or absence of calcifications in the hilar glands with greater certainty than the plain radiographs and at the same time will reveal the relationship of these to the larger bronchi

DEMONSTRATION OF THE MAIN VESSELS IN THE HILAR REGIONS OR LUNGS

The main vessels in the hilar regions can be seen more clearly in tomograms than in plain radiographs especially if they are rather indistinct as a result of local oedema such as may occur in certain cardiac conditions or if they are obscured by superimposed or nearby abnormal lung or glandular shadows Tomograms are therefore indicated in some cardiac conditions to show whether the hilar vessels are enlarged They are also indicated when an abnormally large hilum shadow is seen but there is some doubt whether this is due to prominent or dilated vessels or to glandular enlargement

Demonstration by tomography of the more peripheral lung vessels is indicated whenever it would be helpful to know their relation to an abnormal lung shadow such as an arterio venous aneurysm It is also indicated to show deviation or narrowing of the vessel shadows when emphysema is suspected

DEMONSTRATION OF CALCIFICATIONS IN THE HEART VALVES

Calcification of the heart valves can often be seen on fluoroscopy and it is probable that a more ive use of the screen image amplifier will make their identification even easier If this equipm iot a ailable there is still a place for tomography The left posterior oblique view is the most ry for this purpose and the tomograms should be very well exposed Owing to unavoidabl e ment the image will be blurred to some extent but the intracardiac position of the calcif be firmly established from the layer identification

EXTENT AND POSSIBLE NATURE OF ABNORMAL MEDIASTINAL SHADOWS

The exact extent of an abnormal mediastinal shadow can often be seen in the plain radiographs but sometimes the shadow is so small and indistinct that confirmation of its existence and a demonstration of its exact extent by tomography is indicated In a suspected thymic tumour associated with myasthenia gravis the confirmation and exact delineation of the shadow will influence the decision whether to remove the normal thymus or irradiate the tumour In such a case the tomograms should be taken as lateral views

When the *shadow is obvious there may still be doubt whether it represents a tumour or an aneurysm* and before resorting to angiography the evidence from tomograms should be carefully considered An aneurysm can usually be excluded if the aortic outline is seen independent of the tumour shadow (a finding which may be confirmed by kymograms) or if abnormal high density shadows are detected within the shadow such as bone or teeth suggesting a dermoid cyst or if deep central calcification is seen calcification being only occasionally present in an aneurysm and then nearly always peripheral

In these difficult cases both lateral view and posterior view tomograms are desirable They may be taken simultaneously *with a barium swallow or with an associated pneumomediastinum* A pneumomediastinum can be produced by the presacral introduction of oxygen as used to outline the suprarenals If the patient is kept sitting up some of the gas will diffuse around the mediastinal structures

ADDITIONAL VIEWS IN SUSPECTED LESION OF THE BONES OF THE THORAX

Tomograms of a rib the sternum or the thoracic spine are indicated if a local lesion is suspected in one of these parts but no abnormality can be seen in the plain radiographs or if a lesion is seen in the plain radiographs but is rather indistinct so that there is an element of doubt concerning either the presence or the nature of the lesion

Tomograms may sometimes show erosion of bone from a nearby peripheral bronchial carcinoma or secondary deposit before these can be seen in the plain radiographs Similarly early erosion and periosteal new bone due to an inflammatory lesion may also be shown at an early stage by this method Details of the bone changes may be more clearly seen in tomograms which may aid the diagnosis in a difficult case

Sometimes an opacity is suspected of being in the lung but is unexpectedly found on tomography to be associated with a rib or vertebral lesion

CHAPTER II

THE TIME FACTOR IN X RAY DIAGNOSIS AND COMPARISON OF RADIOGRAPHS OF DIFFERENT DATES

THE TIMING OF INITIAL RADIOGRAPHS

It is rare for an initial radiograph to be premature in chest disease that is within the time interval between suspicious clinical findings and the likely appearance of a shadow By the time the Mantoux reaction is *found to have become positive the shadow of the primary lesion will usually be visible* provided that it is ever going to be A negative radiograph is not necessarily a premature radiograph It is common for the initial radiograph to be normal in bronchial carcinoma but no one would recommend delay in radiography if this condition is suspected following for example a haemoptysis in an elderly man

If the patient is fit enough the initial radiograph is best taken without delay Not only is this an advantage from the point of view of early diagnosis and treatment or an early check radiograph for future comparisons but it also curtails the anxiety which many patients feel while waiting for the result and minimizes the opportunities for postponement due perhaps to the patient s fear of the examination to travel or to domestic difficulties

The state of the patient and availability of the x ray apparatus must of course be taken into account A pleural effusion occurring in a patient who is being treated at home or in a ward remote from x ray facilities would not justify moving the patient at an early stage to the x ray department or summ ng an external mobile unit On the other hand if a ward mobile unit is easily available then the rad h may be taken with this Following a severe but controlled haemoptysis disturbance of the p r the sake of an early initial radiograph would not be justified even if good radiographic fa e *available*

THE TIME FACTOR AS A HELP IN DIAGNOSIS

In some cases when the diagnosis of the nature of the shadow in the initial radiograp the time interval before changes can be seen in serial radiographs may be of some help W homogeneous shadow is seen indicating a lobar consolidation there may at first be doubt c grounds whether it represents a tuberculous lesion or some other infective lesion In the ab of therapy directed towards healing a tuberculous focus rapid resolution would suggest a non tuberculou consolidation Sometimes however an untreated relatively asymptomatic coccal consolidation in a child may persist for some weeks only to resolve rapidly following penicillin therapy

Unfortunately the time interval does not help in differentiating the circular shadow of a circumscribed tuberculous focus from a small bronchial carcinoma or other type of neoplasm Either may grow relatively rapidly or comparatively slowly and a period of observation is not justified in order to make the diagnosis if resection is contemplated

Whether a radiograph is an original one or a follow up of a previous one its date must be given due weight when the x ray appearances are correlated with the clinical and pathological findings The date interval between *comparative radiographs is often of importance and may* either reveal within a certain range the date of origin of a new shadow or give some indication of the time taken for an existing shadow to enlarge or decrease in size

THE TIME FACTOR IN TUBERCULOUS LESIONS

Difficulties of Judging Date of Origin from Initial Radiograph

In most tuberculous lesions the initial or first radiograph cannot indicate the probable date of origin of the lesion A woolly looking ill defined shadow suggesting a lesion of recent origin may nevertheless

have been present for many months and may already have begun to regress while a better defined shadow may have been present for years or may just as well be of quite recent origin

Even the presence of calcifications may be an uncertain pointer to the age of the lesion It is unusual to see calcification in a lesion much under a year after the appearance of a low density shadow and it may be delayed as much as 2 or 3 years

Evidence of lobar shrinkage line shadows or stellate shadows will suggest that some of the lesions are long standing but one of the features of tuberculosis is that foci of quite different dates of origin may co-exist in close proximity so that the presence of some shadows suggesting long standing foci will not exclude the presence of adjacent shadows of much more recent foci Sometimes the more recent foci may be invisible on the radiograph either because they are too small or because they are obscured by superimposed shadows of the denser older lesions

Difficulties of Assessing State of Activity from the Initial Radiograph

That the initial radiograph is of value in drawing attention to a clinically unsuspected tuberculous lesion is well recognized it is also of great value in showing the extent character and distribution of the lesions and forms a base line from which subsequent progress can be observed

The initial radiograph is usually of no value in assessing the activity of the lesion which can only be revealed by the clinical and pathological findings and by changes on subsequent radiographs taken at suitable intervals Even the word active is rarely justified in the x ray report on the initial radiograph Obvious cavities may be present and yet the disease may be stabilized for the present Occasionally in fact a cavity is seen in the radiograph which on resection is found to be epithelialized and without any histological evidence of active tuberculosis Such a finding however is generally only seen after prolonged therapy

A calcified and apparently healed lesion may one day discharge into a bronchus or a vessel so that the demonstration on an initial radiograph of a dense shadow suggesting quiescence may nevertheless be the immediate prelude to an acute spread Such a shadow may also represent a broncholith the tuberculous bronchiectasis being demonstrated only on subsequent bronchograms or tomograms

The finding of tubercle bacilli in the sputum is not uncommon in cases where the appearance of the shadows has led to an x ray report saying old healed tuberculous foci

It is therefore apparent that any conclusions based on the initial radiograph about whether the shadow represents an active stationary or healed lesion are at the best only guesses based on probability and will therefore be found to have a high propensity to observer error if the patient s progress is followed up

Rate of Progress or Regression of Tuberculous Foci

A curious feature of many tuberculous lesions is the uneven manner in which they progress or regress It is a common experience to observe a lesion at monthly intervals for a long period during which there is no change and then sometimes without any obvious alteration in the clinical picture to find that the existing shadow has enlarged or a new shadow has appeared After this incident there may b no further change in the radiographs for several months It is sometimes possible to witness the exact onset of this period of activity if by chance or because of a clinical suspicion of spread radiographs are taken within a few days of each other In one example a second radiograph was taken owing to a clerical error only 4 days after the first and showed extensive new shadowing in the right upper zone due to a local spread from pre-existing tuberculous lesions in this region

The same uneven rate of progression may occur with a small circular shadow with a large circular shadow with a group of shadows and with or without the demonstration of a cavity

This timetable so frequently seen in tuberculosis in which there is an incident with spread occupying a day or two followed by a very much longer period when the lesion is stabilized is an important factor in the diagnosis or assessment of the lesion in many cases

Timing of Serial Radiographs in Tuberculosis

In fixing the time interval between serial radiographs in tuberculosis two principles should be rigorously followed First that it is better to have too short than too long an interval between radiographs and

secondly that if the symptoms or signs change the indications will be the same as for an initial radio graph and a new one should be taken soon—regardless of when the next serial radiograph had been planned

Take for example a patient with tuberculosis whose lesion is apparently under control shadows unchanged and radiographs being taken at 3 monthly intervals A fortnight after the last radiograph he develops a cold which persists for some days perhaps with a trace of sputum This would justify putting forward the next radiograph from 3 months to 3 weeks after the last one

In tuberculosis in the absence of clinical indications radiographs at monthly intervals will often be indicated at first and if these show no changes after 3 or 4 months the interval can be extended to 3 months and eventually to 6 months or a year On the whole the *interval should not exceed 6 months* if a patient is under radiological rather than clinical supervision

In an adult the length of time during which to watch a symptomless small (minimal) lesion presumed to be tuberculous is difficult to fix It should not be less than 3 years for in a series of such patients observed by Springett (1956) enlargement or local spread of the shadows was observed in a large proportion of cases in radiographs taken during the third year of observation the appearances having been unchanged during the previous 2 years Of the patients who still showed no changes in the radiographs after the third year of observation roughly 2 per cent showed evidence of activity as late as the fifth year a figure which is not greatly above that which could have been expected had the initial radiograph been normal

After a tuberculous pleural effusion with no x ray evidence of underlying lung foci observation by serial radiographs should be carried out for 5 years (Thompson 1947)

TIMING OF RADIOGRAPHS AFTER BACTERIAL OR VIRAL PNEUMONIA

In a bacterial or viral pneumonia with signs of consolidation a radiograph is not often required in the initial stages for diagnosis but may be needed if unusual clinical features are present if the physical signs are indefinite or if resolution is slow If resolution is rapid a radiograph should nevertheless always be taken about 6 weeks later to ensure that resolution is complete and to exclude an un t precipitating cause such as bronchiectasis in a young patient or a neoplasm in an older one

TIMING OF RADIOGRAPHS AFTER SURGICAL PROCEDURI

The timing of radiographs after the various surgical procedures used in the treatment of s depends on the wishes of the surgeon in charge The reason for taking such radiogr made known to those concerned with the immediate post operative care of the patient absence of the surgeon his deputy will know when it will be necessary to alter the fixed thoracic unit in this respect

A rough guide to the timing and indications for radiographs in the immediate post operat io is shown in Tables 1 and 2

After exploratory *thoracotomy and many operations on the heart and great* vessels the indications are much the same as after lobectomy Care should be taken to ensure that the final pre discharge post-operative radiograph is a standard anterior view so that the heart size can be compared with the pre operative radiographs and with later post operative ones

COMPARISON OF RADIOGRAPHS TAKEN ON DIFFERENT DATES

Serial observation of lesions being one of the most important uses of radiology in chest diseases it is important to make full use of the method and not to undermine its validity with avoidable mistakes

All the radiographs should be of first rate quality or if a difference in quality is unavoidable at least amenable to accurate comparison If possible and in the absence of unavoidable alterations the shadows should bear the same orientation to each other in each film *Ideally the radiographs should be* inspected and a careful assessment of any change made by at least two observers

Causes of Observer Errors

The comparison of shadows in two radiographs taken of the same chest at different times is often considered a simple matter and the interpretation is often perfunctory and hurried The fact that it is not easy is shown by observer error tests carried out recently with two series of comparative radiographs

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TABLE 1

Radiology after Some Surgical Procedures

Operation	*Timing of skiagrams*	*Purpose of skiagrams*	*Clinical significance of x-ray findings, and possible action indicated*
Pneumonectomy	24–48 hours	To show quantity of fluid	If on tube drainage should be no fluid. If not, fluid should be below bronchial stump
		To show mediastinal displacement	If excess, introduce air into pneumonectomy space.
	4th or 5th day	Similar	Similar
	10th day	Similar	Similar
	3rd week	Similar	Preferably no fluid or very little. Mediastinal displacement probably considerable by now. May require surgical steps to counter act it.
Lobectomy	24 hours	To show re-expansion of remaining lobe(s)	If poor increase suction drainage. Measures to clear bronchus such as expectoration. X ray next day to see if effective
		To show quantity of pleural fluid	If much aspiration
	4th or 5th day	Similar (special watch for contralateral spread)	Similar
	10th day	Similar but also take lateral view	Ensure no anterior or posterior pockets of fluid.
	No immediate further x rays unless re-expansion incomplete or residual fluid or complications present		
Thoracoplasty	24–48 hours	To show size of air bubble and quantity of extrapleural fluid	To gauge size of apicolysis "dead space"
		Exclude pneumothorax	To ensure pleura not opened accidentl
		To show clarity of lower part	To ensure good aeration.
	4th or 5th day	To show size of air bubble	Should be smaller
		To show quantity of fluid	Aspiration, if excessive
		To show surgical emphysema	Should have disappeared.
		To show clarity of lower part	Investigate cause if still opaque
		To show pleural fluid	Aspirate if necessary
	12th day	To show air bubble and fluid	Should be much less.
		To show degree of scoliosis	Attention of physiotherapist if excessive
	Before further stage if any	Ensure no contralateral spread good aeration of compressed lung no pleural fluid	
Extrapleural pneumothorax	24 hours	To show size of air space and fluid level	For comparison with next films.
	48 hours	No increase in fluid level	If excessive increase find cause
		No descent of opaque area	Would suggest pleural stripping by bleeding.
	5th–8th day	To show quantity of fluid	Aspiration, if excessive
		To show degree of lung re-expansion	Air replacement, if necessary
	12th day	Similar	Similar

It was found that there was a considerable difference of opinion when it came to deciding whether the condition was better unchanged or worse not only between the different observers but between the same observer re reading the radiographs on another occasion

One of the series consisted of a very large number of radiographs showing small (minimal) non cavitated symptomless tuberculous foci A conference between the observers was held after the test to discuss the considerable number of radiographs about which there had been a difference of opinion It was decided that there were not many errors due to shadows being missed either locally or in another zone but that there were a great number of disagreements (10 per cent) about whether shadows which had been seen by all observers had become smaller or larger between one radiograph and another These disagreements were in the main put down to differences from one comparative radiograph to the next in the orientation of the shadows in relation to each other and the (posterior) ribs There

TABLE 2

COMPLICATIONS OCCURRING AFTER SOME SURGICAL PROCEDURES AND THE X RAY CHANGES LIKELY TO BE SEEN WITH THEM

Operation	*Clinical findings*	*Possible x ray findings*
Pneumonectomy	High fever rapid pulse and distress	Too much fluid
		Contralateral lesion such as atelectasis
Lobectomy	Fever rapid pulse and distress	Too much fluid
	Restriction of movement rapid pulse and distress —usually on the 2nd or 3rd day (Less likely in tuberculosis than in bronchiectasis as there is less secretion in the upper respiratory tract or bronchi)	Contralateral lesion
Thoracoplasty	Fever rapid pulse and distress	Opaque area extending lowe indicating str of Semb s space
		Opacity suggesting ollapse of lower l after 2nd stage
		Occasional contralateral atelect
Extrapleural pneumothorax	Rapid pulse and pallor Distress due to pressure of fluid	Increased fluid level from haem r

were practically no disagreements which could be attributed to differences in exposure on technique although the differences in the quality of the radiographs was sometimes very cons le It was agreed that where some shadows had resolved but new ones had appeared the condition should be considered to have deteriorated but even with this help there was a small residue of cases in which the disagreement could not be resolved

In the second series the comparative radiographs showed a more complicated pattern of shadows and the same persistent disagreement was found on an even larger scale

A Suggested Routine Method for Comparing Serial Radiographs

If it is done in a careful systematic manner comparison of shadows though not always easy may yet be consistent and fairly accurate It is essential that the radiographs should be viewed together side by side and for this purpose a suitable viewing box or two such boxes should be available giving an even illumination of both radiographs A routine inspection can then be made on the following lines

Identity of patient

The identity of the patient should be confirmed not only by checking the name and number on both radiographs but by observation of some obvious anatomical landmark such as a cervical rib bifurcated rib unusual shape or notch on any rib degree of calcification of the costal cartilages and the size of any extrathoracic soft tissue shadows particularly breast shadows

Dates of radiographs

The dates should be noted and the radiographs arranged in their date order

Gross discrepancy in quality

Any gross discrepancy in the general density or contrast of the films should be noted and taken into account when interpreting the films If it is such that it is likely to make comparison difficult it may be possible to reject the last radiograph and take another of more appropriate quality to replace it

Orientation of subject

The lateral orientation of the subject in the two radiographs should be compared by noting the position of the sternal ends of the clavicles in relation to the vertebral margins

Centring

Finally the centring should be compared by noting the distance of the top of the apical translucency from the clavicle on one side any difference indicating either that the x ray beam is centred higher in one film than the other or that the patient is leaning farther forwards A more delicate test is to count the number of posterior parts of the rib shadows lying above the level of the clavicle and noting any difference in the two radiographs Here again it may be necessary to take further radiographs so that comparison can be made between radiographs in which the orientation of the shadow to the x ray beam is similar

CONFIRMATION OF DIFFERENCES SEEN

When changes are seen which may be an important factor in deciding on the next phase of treatment it is often wise to confirm the appearances with different views perhaps a posterior view and a lateral view and if necessary a tomogram

When the differences are slight it is often useful to compare the last radiograph not only with the previous one but with another one taken some time before that so that a slowly progressive rather insidious increase in shadowing may be seen more easily

APPENDIX

SOME HINTS ON X-RAY TECHNIQUE

STANDARD ANTERIOR VIEW

THE STANDARD anterior view is taken at a tube film distance of 5-6 feet the patient usually standing with breath suspended in deep inspiration

POSITION OF PATIENT

The body should above all be in an unstrained position otherwise slight movement may occur and the vertebral borders of the scapulae are likely to be superimposed on the lung fields In order to encourage a relaxed position the distance between the top of the x ray film and the bar on which the chin rests should be kept as short as possible and should not exceed 2 centimetres otherwise the neck will either be hyperextended when the chin is over the top of the bar or the apices will be too far from the film because the chin cannot be placed well forwards There should be a free space of at least 10 centimetres above and behind the cassette so that the chin and head can be placed well forwards

If the backs of the hands rest lightly on the postero lateral parts of the iliac crests the elbows can be placed well forwards so as to bring the scapulae laterally and well forwards This position ensures more relaxation than if the thumb and index finger are separated and grip round the side of the iliac crests

CENTRING OF THE X RAY BEAM

The x ray beam should in theory be centred on the fourth thoracic vertebra but in practic [illegible] g on a fixed level of the cassette (usually a third of its length from the top) is much easier a [illegible] Such a mark though not as accurate in relation to the patient as an anatomical landm [illegible] one can be easily felt) is nevertheless reasonably consistent being a fixed distance fr [illegible] chin which rests on the top of the cassette

The correct orientation of the x ray tube in relation to the cassette can be obtained [illegible] giving distances from floor level are available on or near the cassette holder and the colu [illegible] the tube A second method is the use of a simple sighting device fixed onto the tube by n [illegible] the tube is aimed at the correct level on the cassette A third method is to have the cas [illegible] connected to the tube by a link cable which ensures that the two retain their relation to each [illegible] when moved up or down The design of the link cable must be such that it can be rapidly disconnected or neutralized if another relationship between cassette and tube is required as in radiography of children when a smaller film is used lower down in the cassette holder or for a standard lateral view when the tube is directed towards the middle of the cassette or for some special view taken with the tube at an angle

TECHNIQUE WITH CHILDREN

Children can generally co operate as well as adults especially if a little time is spent gaining their confidence and giving them practice in taking a deep breath and holding it for a few seconds If they are so young that they cannot do this quite satisfactory radiographs can be obtained even while they are breathing quietly provided the exposure time is kept short (about 0 04 second)

With electronically controlled circuits the very short exposure times probably correspond to the figures indicated on the clock but this is not the case with some other types of apparatus in which the effective exposure below 0 04 seconds is often shorter than the clock setting would suggest because the first impulse and perhaps the second also does not allow for a full pulse of current In addition a very short exposure may actually vary in length from one occasion to another in spite of a fixed clock setting It is therefore best to use the shortest time found by experience to give consistently satisfactory

radiographs rather than to be too concerned with the figures on the clock On the whole a setting as low as 0 02 does not give satisfactory results on many sets

The time of exposure for a given milli amperage can be shortened by raising the kilovolts but it is best to use a value of kilovolts which will give the degree of contrast in the radiograph best suited to the particular observer

There is no great objection to shortening the time by reducing the distance A reduction from 6 to 4 feet will allow the exposure time to be halved In small children a shadow even near the back of the chest is not very far from the film so that it is not likely to be indistinct on this account

Very young children are best radiographed sitting on a small seat and holding on to a bar fitted just behind and projecting to either side of the cassette The breathing should be watched and the exposure made towards the end of the inspiratory phase

TECHNIQUE WITH BABIES

A baby is best radiographed sitting with its back to the cassette on a suitably padded seat An anterior view is often not impossible but the baby is more easily controlled and kept in a straight position when sitting with its back to the cassette The mother if available can hold the baby s arms up against the sides of the head and thus control both the body and head It is an advantage to have a restraining band over the knees and thighs so that the mother can exert a gentle upward pull against it to straighten the back and diminish the tendency of the body to fold forwards with a kyphotic curve

Restraint of babies should not be undertaken by nurses or assistants working regularly in the x ray department owing to the possibility that they might receive an excessive dose of x rays if they were to hold many babies during a week Done only occasionally the support or restraint of a patient is of course quite harmless

If a baby is very restless when sitting up a supine view can be taken with the cassette covered with a warm soft towel and the baby lying on it With this view special care must be taken to position the baby so that the clavicles are symmetrical Slight rotation results in considerable displacement of the mediastinal contents giving a confusingly wide mediastinal shadow—a feature which is further accentuated if the diaphragm is high because the exposure is taken during forced expiration often with the child crying (Fig 159) In such circumstances a more normal appearance may be seen in a subsequent radiograph taken a few seconds later with less rotation and during inspiration (Fig 160)

Fluoroscopy is of value when examining babies because a normal mediastinal shadow may be seen during the brief moment of full inspiration A short series of radiographs taken with the baby lying on the angiocardiography cassette changer consisting of six exposures in 8 seconds may also help by producing at least one radiograph taken during inspiration

ANTERIOR VIEW TAKEN WITH PATIENT LYING DOWN

A radiograph taken with an adult patient lying down is often useful to displace the breast and nipple shadow or to show the disappearance of a suspected fluid level The patient may be supine but an anterior view taken with the patient prone will be more comparable with the routine anterior view taken standing One end of the cassette should be raised 2 inches by means of a small sand bag towel or block so that the patient s chin can lie comfortably above the cassette (Fig 158) The position of the patient s chin arms and hands can thus be the same as in the standing view Unless a low table is available the tube film distance may have to be less—if a distance of at least 4 feet cannot be obtained in any other way it may be necessary in some cases to put a rug on the floor and place the cassette on this

An anterior (P A) view with the x ray beam horizontal to the floor and the patient lying on one side with his back to it is useful at times particularly to show the shift of the shadow if a small effusion or intracavitary loose body is suspected

LORDOTIC AND SIMILAR VIEWS

A lordotic view is taken with the x ray beam horizontal and the patient sitting and leaning backwards towards the cassette at an angle of some 30 degrees if possible with the back arched—hence the name lordotic view The position is uncomfortable and difficult to hold while the more the back is arched the greater the tendency for the scapulae to move medially and be superimposed on the lung fields

A much more satisfactory procedure giving an almost identical projection is for the patient to stand facing the cassette as in a standard anterior view, and the x ray tube to be raised and angled downwards 45 degrees and centred over the spine of the second thoracic vertebra (Fig 157) It is usually necessary to reduce the distance between the film and tube column to 4 feet since the vertical elevation of the tube may not otherwise be sufficient This view not only serves to show the shadow of a shrunken middle lobe as clearly as a lordotic view but is also satisfactory as an additional view of the apices which are projected below the shadow of the clavicles

If the patient cannot sit or stand a reverse view may be obtained with the patient supine and the x ray beam angled 45 degrees towards the head and centred just above the xiphisternum

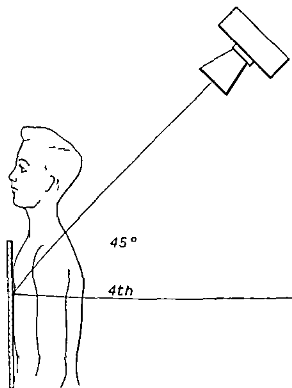


Fig 157—Taking a reverse lordotic view Diagram to show the position of the cassette and the patient and the 45 degree downward angulation of the x ray tube

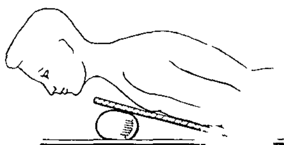


Fig 158—Taking an anterior view with the [illegible] Diagram to show how slight elevation of one end of the cassette makes the patient s position comparable to that of a standing patient during routine anterior view radiography

APICAL VIEWS

An apical view may be taken as described above with the x ray beam tilted 45 degrees towards the feet or it may be taken with the tube angled 30 degrees upwards towards the head and centred on the spine of the sixth thoracic vertebra thus throwing the shadow of the lung apex well above the clavicle

ANTERO POSTERIOR VIEW

An antero-posterior view may at times show shadows invisible in a postero anterior view If possible it should be taken with the hands and arms in the same position as the standard view to keep the shadow of the scapula as far as possible clear of the lung field

This view will often confirm the presence of very small or indistinct shadows better than a magnification technique or the use of a very low kilovoltage

THE LATERAL VIEW

A lateral view with a fit patient presents no particular problems There is a tendency to over expose the film and then under develop it thus producing a radiograph with poor contrast or to under expose and produce a radiograph with insufficient blackening Assuming standard development a well exposed radiograph will be easier to interpret than an under exposed one

An average patient will require 200 mA 70 kVp 0 1 seconds at a tube film distance of 4 feet An old or ill patient may be rather unsteady but will tend to sway less if radiographed sitting instead of standing A fit patient can be radiographed with the arms held almost vertically but an ill patient may find it easier to raise them only to a right angle and clasp the hands behind the head with the elbows parallel In this position or with the help of a bar fixed at a suitable level in front of and above the cassette which the patient can grasp radiographs free from avoidable movement can be obtained

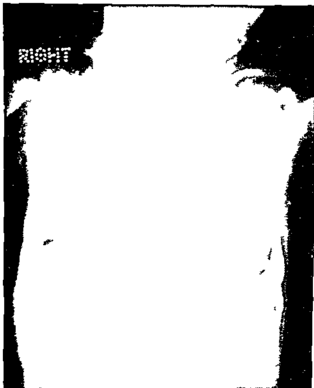


Fig 159 —Radiograph of a normal child taken during expiration and crying High position of diaphragm and wide central shadow



Fig 160 —Same case Radiograph taken a few second later with breath in full inspiration and no crying The appearances are now normal

In fat subjects a Potter Bucky diaphragm or fixed grid will result in a radiograph with more contrast but with many kinds of grid there is a slight loss of sharpness of the image which tends to diminish the advantages of the increased contrast

THE OBLIQUE VIEW

For an oblique view the patient should be positioned at an angle of rotation most suitable for the purpose in hand A collapsed lower lobe or calcified heart valve is best seen at 45 degrees rotation whilst the left oblique view for a bronchogram or for the heart and aorta is best taken at 60–70 degrees (that is biased towards a lateral view) Frequently the most appropriate angle can only be determined by preliminary fluoroscopy

MAGNIFICATION OF THE IMAGE

Magnification of the image is very helpful when there is doubt whether some very small circular shadows are present or not as in a doubtful case of pneumoconiosis small tuberculous lesions sarcoidosis

or any other lung lesion likely to give small indistinct shadows It is also useful for the identification of the hair line of a fissure

It is most easily done with a suitable magnifying glass giving an image 2–4 times the natural size Only a limited degree of magnification is possible before the inherently granular appearance of the film emulsion becomes indistinguishable from possible pathological shadows

Direct enlargement of the shadows can be achieved by placing the film some 12–18 inches from the patient and by working with a fine focus x ray tube at a short tube film distance of 4 feet but this is accompanied by considerable unsharpness or blurring of outline of the shadows Using a standard x ray tube with a fine focus of about 1 millimetre the enlarged image of a small 0 5–2 millimetre lesion is no easier to see than one in a standard radiograph viewed through a magnifying glass By using an x ray tube with a very fine focal spot of 0 3 millimetre a more satisfactory image may be obtained by direct enlargement

IDENTIFICATION MARKS ON FILMS AND SEPARATION OF KEY FILMS

It is worth while giving some thought to the details of dating and marking films and also to the separation of key films out of the large quantity of chest x rays often taken of one patient These things enable the radiological features of a particular cas to be grasped with ease and comfort without irritating distractions

Radiographing of Lead Numeral Dates

The dating of chest radiographs should be bold and clear so that the time interval between each of a series can be readily appreciated Lead dating numerals (¼–½ inch high) can be radiographed onto the film at the same time as the patient s chest If these numerals are placed in a fixed position to one side and in front of the cassette they will also serve to show in a case of doubt whether the view taken was antero posterior or postero anterior right or left lateral and in a known standard postero-anterior view whether there is any transposition of the thoracic viscera The radiographed lead lettering is on the whole easier to read than lettering made on the film with a pin point perforating machine or written on by hand

Photographic Printing of Patient s Name and Number

The patient s name and number can either be written or photographed onto the film before it is developed The photographic method is efficient and time saving and is done with a light proof box in which the electric light source is enclosed This box has a flat top (large enough to take the largest size of film) in one corner of which a window about 6 centimetres by 2 5 centimetres is provided A corresponding corner of the x ray film is protected from the x rays by means of a piece of lead the same size and 1-2 millimetres thick fixed permanently on or in the cassette The patient s name and number are written within a space of 6 centimetres by 2 5 centimetres on one corner of a white transparent card which is placed in front of the window The x ray film exposed but not developed is placed on the top of the card and good contact between the film and the card ensured by means of a well padded hinged flap which can also be used when pressed down to actuate the electric light switch To ensure that the same exposure is given to each film the light must be kept on for the same time which is best done by some timing device such as a condenser discharge circuit The film is then developed in the usual manner

The card used for the purpose of photographing the name of the patient on the film should be of even texture to avoid a granular background Cards made from cloth pulp are most likely to be suitable in this respect The name can be written on the card with almost any ink or with a typewriter—red ink or pencil often giving suitable results Insufficient opacity of the ink is not usually a cause of illegibility which is more likely caused by excessive granularity of the card inadequate light exposure or poor contact between the card and the film during the light exposure

Direct Marking for Legibility without Transmitted Light

Unfortunately neither the name photographed nor the date radiographed on the films can easily be read except by transmitted light To facilitate placing the radiographs rapidly in the correct order

according to the dates on which they were taken a serial numeral 1 2 3 4 and so on should be written clearly in white ink or in yellow red or green grease pencil on to each film after development The order in which they were taken can thus be found without the necessity of holding them up in front of a viewing box to read their individual dates

Selection and Marking of Key Radiographs

In some chest diseases a large number of films may be taken over a period of years and many of these may become of little value to the patient or his physician in the course of time In this category are films taken over a long interval during which there was no change or the immediate post operative radiographs in an uncomplicated case which may only be of interest for research purposes

It is sometimes convenient to select a sample from these many radiographs illustrating the important features particularly when the appearances have changed These can either be marked in some way to indicate that they are key radiographs or kept in a separate envelope inserted in the main envelope or in one side of a partitioned envelope the remainder being placed in the other side Tomograms are usually taken on a smaller sized film and are thus easily placed in smaller envelopes inserted in the main one

DARK ROOM TECHNIQUE

A number of chest radiographs of poor quality are still seen each year and in the majority of cases this is due to faults in the dark room causing fogging of the film most of which could easily be avoided or corrected

Faulty Storage

Faulty storage may result in a general grey fogging of the films Before use films should be kept in a reasonably cool place and not kept for too long Boxes should be numbered or dated as they are received and used in the same order to avoid the risk of an odd box lying around for too long a period All risk of fogging of the films from stray radiation from diagnostic or therapeutic x rays or the emanations of radio active substances in nearby rooms should be eliminated

Excess of Light

Light fogging may occur if blinds doors or light traps are faulty, or the filters of the dark room lights are defective A test to eliminate such sources of unwanted light should be made from time to time

Chemical Fogging

Chemical fogging can be avoided by keeping the developing solution at the correct strength and temperature and seeing that the time of development is adjusted to this Topping up with special replenisher solutions is a help in keeping the developing process reasonably constant while there are very few departments that are not busy enough to justify thermostatically controlled units

Washing of films between the developer and the fixer must be carried out with care so that no excess of developer or water is carried from one tank to another

Fixing solutions must be discarded before they become exhausted or cause staining of the films Modern electrolytic methods of collecting the unused waste silver from the fixer are efficient and an economic proposition and will keep the solution in a satisfactory state for months the level being kept up by the addition of fresh solution and the *pH* kept between 4 and 5 (optimum 4 2) This can be checked daily with an indicator paper or a solution of bromocresol purple A small quantity of 5 per cent acetic acid should be added to the fixing solution until the right colour is registered by the indicator

TOMOGRAPHY

Types of Apparatus

Many types of apparatus are available for tomography and the type already installed in the department will be the one to use Provided that the x ray tube column and the Potter Bucky diaphragm run

independently there is no excuse for anyone not employing this valuable method of investigation since a very simple home made coupling (such as the one originally introduced by Twining 1937) can produce very satisfactory tomograms

Various refinements on this simple principle include vertical coupling a V shaped contactor to keep the current on over a given arc of swing devices for propelling the tube column at a given constant rate of movement full mechanization with the layer selection and the preparation of the column for its final run controlled electrically with push button switches and complications of the x ray tube or film movements such as a figure of eight swing of the tube and dipping of the Potter Bucky diaphragm with or without image magnification

All these refinements may facilitate the ease with which the investigation is carried out or contribute to the consistency of the tomograms but they will not greatly improve their quality The most important factors controlling the quality are smooth running of the tube column and Potter Bucky diaphragm tray so that there is no blurring from unwanted movements and a satisfactory Potter Bucky grid which produces good contrast sharp detail and no visible grid lines

Checking Calibration

The calibration of the apparatus should be checked once to see that the figures marked on the scale do in fact correspond to layers the same distance from the table top If lead numerals are placed parallel to the film on wooden steps at intervals of for instance 3 4 5 6 and 7 centimetres from the table top and the layer selector is set for 5 centimetres and an exposure made it will be possible to judge from the tomograms whether the 5 centimetre numeral has come out most clearly and the calibration is therefore correct or whether some other numeral is the clearest in which case the appropriate correction of the scale could be made

Marking of Layer Depths on Films

The layer depths are best marked on the films by placing bold lead numerals approximately 1 5 centimetres in size on the cassette and radiographing them along with the patient

The Arc of Swing

The arc of swing should be about 25 degrees from the vertical when working at a tube film distance of 36-40 inches Increasing it to 50 degrees decreases the contrast slightly without showing cavities or small foci any more clearly If the swing is much less than 25 degrees the visible layer becomes too wide and the individual shadows too indistinct so that small cavities or foci may pass undetected

Centring of the X ray Beam

Centring of the x ray beam will of course depend on the information being sought The level of an abnormal shadow in relation to the clavicle can be measured on the plain radiograph and the beam centred onto this point The main bronchial and hilar shadows lie roughly at the level of the sternal angle or second costal cartilage

Except for comparative tomograms of known localized opacities quite a large area should be included (10 by 8 inches or 12 by 10 inches) since features invisible on a plain radiograph are often seen on tomograms Very accurate centring by means of fluoroscopy has therefore no great advantage over centring in relation to some easily palpable landmark By omitting fluoroscopy no time is wasted waiting for the eyes to become adapted to the dark In any case few radiographers are skilled at fluoroscopy *and few radiologists have the time to do more than supervise the resulting films*

Selection of Layers

The selection of layers depends particularly on the information being sought If the radiologist cannot be present the radiographer must be carefully briefed about the purpose of the examination and the layers and region required

When possible the tomographs should be inspected as soon as they are fixed and before the patient is moved so that any additional layers found to be necessary can be taken under identical conditions Once the patient has been moved it is difficult to place him in exactly the same position again and a

cavity seen at a level of 5 centimetres on one occasion may only be seen at a level of 6 centimetres on another Additional layers taken on a second occasion must therefore cover a wider range than would have been necessary had they been taken there and then

Errors of exposure faulty centring or a suspected deficiency in the range of layers can all be best corrected at a single session In fact the most reliable results can only be obtained if each case is handled separately and given individual attention the technique being adapted to it with the same skill and care as is used for instance in a gastro intestinal examination personally undertaken by the radiologist

SIMULTANEOUS MULTISECTION TOMOGRAPHY

Simultaneous multisection tomography is a method whereby five different layers may be tomographed simultaneously with a single exposure and a single swing of the x ray tube The method was considered mathematically by Ziedes de Plantes (1933) and applied practically by Watson (1951 and 1953) The

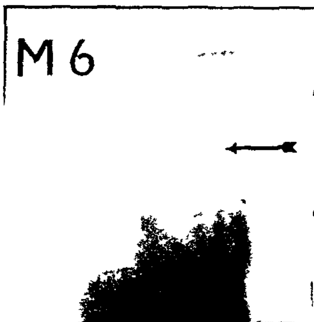


Fig. 161 —Simultaneous multisection tomogram (one of 5 layers taken simultaneously with a single exposure and a single tube film movement) Arrow points to the ring shadow of a tuberculous cavity in the right upper zone



Fig 16 —Same case Conventional single layer tomogram Same mA and time but 10 kVp less The film is rather blacker and has more contrast but the ring shadow (opposite arrow) is no clearer

author examined a series of patients both by this method and by conventional tomography and the findings were compared with the specimens after resection Although the radiographs by the multi section method had rather less contrast and were rather greyer than by the other method small foci and small cavities were shown equally well by both (Figs 161 and 162) The saving in time and energy is considerable and for this reason alone the method is valuable in many cases

Saving in Radiation Dosage

The saving in the amount of radiation received by the patient is also considerable although in view of the relatively small dose received even in conventional tomography this is not an important factor generally In special circumstances however when children are being tomographed or when simultaneous bronchography or aortography and tomography is being done or when a patient has recently received a lot of radiation simultaneous multisection tomography has obvious advantages

Table 1 shows the total skin dosage of radiation received by patients during lateral view tomograms of the chest taken by both methods under routine working conditions Obtaining the identical five layers by simultaneous multisection tomography entailed a dose one-quarter of that received during the five separate swings of the conventional tomography

TABLE 1

TOTAL SKIN DOSAGE OF RADIATION RECEIVED DURING LATERAL VIEW TOMOGRAPHY (200 MA SECS)

	Type	kVp	Dose per swing roentgen units	Total dose for five layers roentgen units
St Bartholomew's Hospital (Mr G S Innes)	Conventional	75	4	20
	Multisection (five layers)	85	5 1	5 1
Cancer Hospital (Dr G Spiegler)	Conventional	80	8	40
	Multisection (five layers)	90	10	10

THE TECHNIQUE

Simultaneous multisection tomography can be used with most types of x ray couch provided there is easy access to the clear space beneath the tray of the Potter Bucky diaphragm

The five films are placed in a light proof box with a radio translucent front They are spaced 1 1 centimetre apart by balsa wood or plastic sheets The tray of the Potter Bucky diaphragm is withdrawn and the box put in its place so that the uppermost film lies in the same position as the single film would occupy in conventional tomography The layer reproduced on this top film will then correspond to that to which the layer selector is set and the other four films will reproduce lower layers 1 2 3 and 4 centimetres respectively nearer to the table top level

Since intensifying screens tend to absorb a lot of x rays a special combination of them is indicated to avoid under exposure of the lower films The following combination of intensifying screens is satisfactory for a range of 50–90 kVp

(1) Single high definition screen
(2) Single ordinary standard screen
(3) *One pair of high definition screens*
(4) One pair of ordinary standard screens
(5) One pair of high voltage screens

All intensifying screens except the last must be front screens The first screen beneath the front of the box should be facing the floor

Ilford or Kodak screens and Kodak Blue Brand or Ilford Red Seal films have been found to result in an even density throughout the five film series

The exposure will be the same mA seconds as for conventional tomograms but an increase of 10 kVp will be needed The side of the first two balsa wood spacers which lies directly against the first two films should be covered with a thin sheet of paper which will absorb some of the scatter radiation from the spacers Both paper and screens should be stuck to the spacers to ensure rapid loading and unloading of films in the dark room

MARKING OF SIMULTANEOUS MULTISECTION TOMOGRAMS

If the upper screen of each layer has a serial number written on it in black marking ink this number will appear faintly on each of the exposed films since there will be no fluorescence through the ink Later after development the films are assembled in numerical order and the depths written on them in white ink or grease pencil starting at number 1 with the depth indicated on the layer selector Lead markers would tend to show on all five films and are best avoided A strip of lead placed in a suitable position on the front of the box will enable the usual photographic name and date identification to be carried out if this is in routine use

REFERENCES

Annotation (1950) The Nomenclature of Broncho-Pulmonary Anatomy *Thorax* 5 222
— (1954) Observer Error *Lancet* 1 87
— (1955) Diagnosis of Pericardial Effusion *Lancet* 1 91
Bourne G (1949) *An Introduction to Cardiology* p 17 London Arnold
Boyden E A (1955) *Segmental Anatomy of the Lungs A Study of the Patterns of the Segmental Bronchi and Related Pulmonary Vessels* New York McGraw Hill
Brock R C (1954) *The Anatomy of the Bronchial Tree* 2nd ed London Oxford University Press
Cochrane A L and Garland L H (1952) Observer Error in the Interpretation of Chest Films *Lancet* 2 505
Cunningham G J and Parkinson T (1950) Diffuse Cystic Lungs of Granulomatous Origin *Thorax* 5 43
Dolton E G and Jones H E (1952) Congenital Anomalies of the Aortic Arch *Lancet* 1 537
Dornhorst A C and Pierce J W (1954) Pulmonary Collapse and Consolidation *J Fac Radiol* 5 276
Fisher R E W and Makin R (1952) Pulmonary Haemosiderosis *Lancet* 1 540
Fleischner F G (1941) Linear Shadows in the Lung *Amer J Roentgen* 46 610
Fletcher C M (1948) Pneumoconiosis of Coal Miners *Brit med J* 1 1065
— (1949) The Classification of Radiographic Appearances in Coalminers Pneumoconiosis *J Fac Radiol* 1 40
Garland, L H (1950) On the Reliability of Roentgen Survey Procedures *Amer J Roentgen* 64 32
Glendinning A C (1954) Occasional Bronchography *Lancet* 2 1253
Greenfield, I (1943) Spring Water Cyst of the Mediastinum *J thorac Surg* 12 495
Hamman L and Rich, A R (1944) Acute Diffuse Interstitial Fibrosis of Lungs *Johns Hopk Hosp Bull* 74 177
Harley H R S and Drew C E (1950) Cystic Hygroma of the Mediastinum *Thorax* 5 105
Harold J T (1954) Chronic Descending Pulmonary Tuberculosis *Brit J Tuberc* 48 24
Hodges F J and Eyster J A E (1926) Estimation of Transverse Cardiac Diameter in Man *Arch intern Med* 37 707 A reproduction of the chart is also given by Bourne (1949)
Kerley P J (1951) *See* Shanks S C and Kerley P J (1951)
Morgan A D Lloyd W E and Price Thomas C (1952) Tertiary Syphilis of the Lung and its Diagnosis *Thorax* 7 125
Newell R R Chamberlain W E and Rigler L (1954) Descriptive Classification of Pulmonary Shadows *Amer rev Tuberc* 69 566
Oswald N C and Parkinson T (1949) Honeycomb Lungs" *Quart J Med* 18 1
Philip W Paton Harrison K and Cruickshank D B (1954) A Posterior Mediastinal Dermoid Tumour with Marked Anatomical Differentiation *Thorax* 9 245
Pierce J W (1953) Pulmonary Manifestations of Fungous Diseases In *Modern Trends in Diagnostic Radiology* (Second Series) London Butterworth
Pryce D M Sellors T H and Blair L G (1947) Intralobar Sequestration of Lung Associated with an Abnormal Pulmonary Artery *Brit J Surg* 35 18
Reid L M (1955) Correlation of certain bronchographic abnormalities seen in chronic bronchitis with the pathological changes *Thorax* 10 199
Scadding J G (1952) Chronic Lung Disease with Diffuse Nodular or Reticular Radiographic Shadows" *Tubercle Lond* 33 352
Shanks S C and Kerley P J (1951) *A Text Book of X Ray Diagnosis* 2nd ed 2 318 London Lewis
Sharp M E and Danino E A (1953) An Unusual Form of Pulmonary Calcification Microlithiasis Alveolaris Pulmonum *J Path Bact* 65 389
Simon G (1949) *X Ray Diagnosis* p 174 Cambridge W Heffer
— (1952) The Lateral Position in Chest Tomography *J Fac Radiol* 4 77
Smart J and Thompson V C (1947) Intra Thoracic Lipomata *Thorax* 2 163
Springett V H (1956) *Minimal Pulmonary Tuberculosis found by Mass Radiography (Fluorography)* London Lewis
Store S D (1954) A Case of Pulmonary Hamartoma *Brit med J* 1 25
Thomas C P and Drew C E (1953) Fibroma of the Visceral Pleura *Thorax* 8 180
Thompson B C (1947) Prognosis of Primary Pleurisy with Effusion *Brit med J* 1 487
Turkington S I Scott G A and Smiley T B (1950) Leiomyoma of the Bronchus *Thorax* 5 138
Twining, E W (1937) Tomography by means of a simple attachment to the Potter Bucky Couch *Brit J Radiol* 10 332
Van Allen C M Lindskog G E and Richter H G (1931) Collateral Respiration Transfer of Air Collaterally between Pulmonary Lobules *J clin Invest* 10 559
Waring J J (1955) The Pathogenesis and Prognosis of Tuberculous Pleurisy with Effusion *Tubercle Lond* 36 59
Watson W (1951) Simultaneous Multisection Tomography *Radiography* 17 221
— (1953) Simultaneous Multisection Tomography In *Modern Trends in Diagnostic Radiology* (Second Series) London Butterworth
Whitaker W (1954) Total Pulmonary Venous Drainage through a Persistent left Superior Vena Cava *Brit Heart J* 16 177
White P D (1951) *Heart Disease* 4th ed p 144 New York Macmillan
Wood P (1950) *Diseases of the Heart and Circulation* p 63 London Eyre and Spottiswoode
Ziedses des Plantes B G (1933) Planigraphie *Fortschr Rontgenstr* 47 407

INDEX

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